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BELL
TELEPHONE QUARTERLY

VOLUME XV, 1936



INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

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VOLUME XV, 1936

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DL. XV

JANUARY, 1936

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TELEPHONE RESEARCH AND PROBLEMS OF
THE DEAFENED

COMMUNICATIONS AND POLICE PROTECTION

ENGINEERING THE TELEPHONE FLEET

A DECADE OF AWARDS TO THE SCIENTISTS
AND ENGINEERS OF THE BELL TELEPHONE
SYSTEM

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK



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*A Medium of Suggestion
and a Record of Progress*

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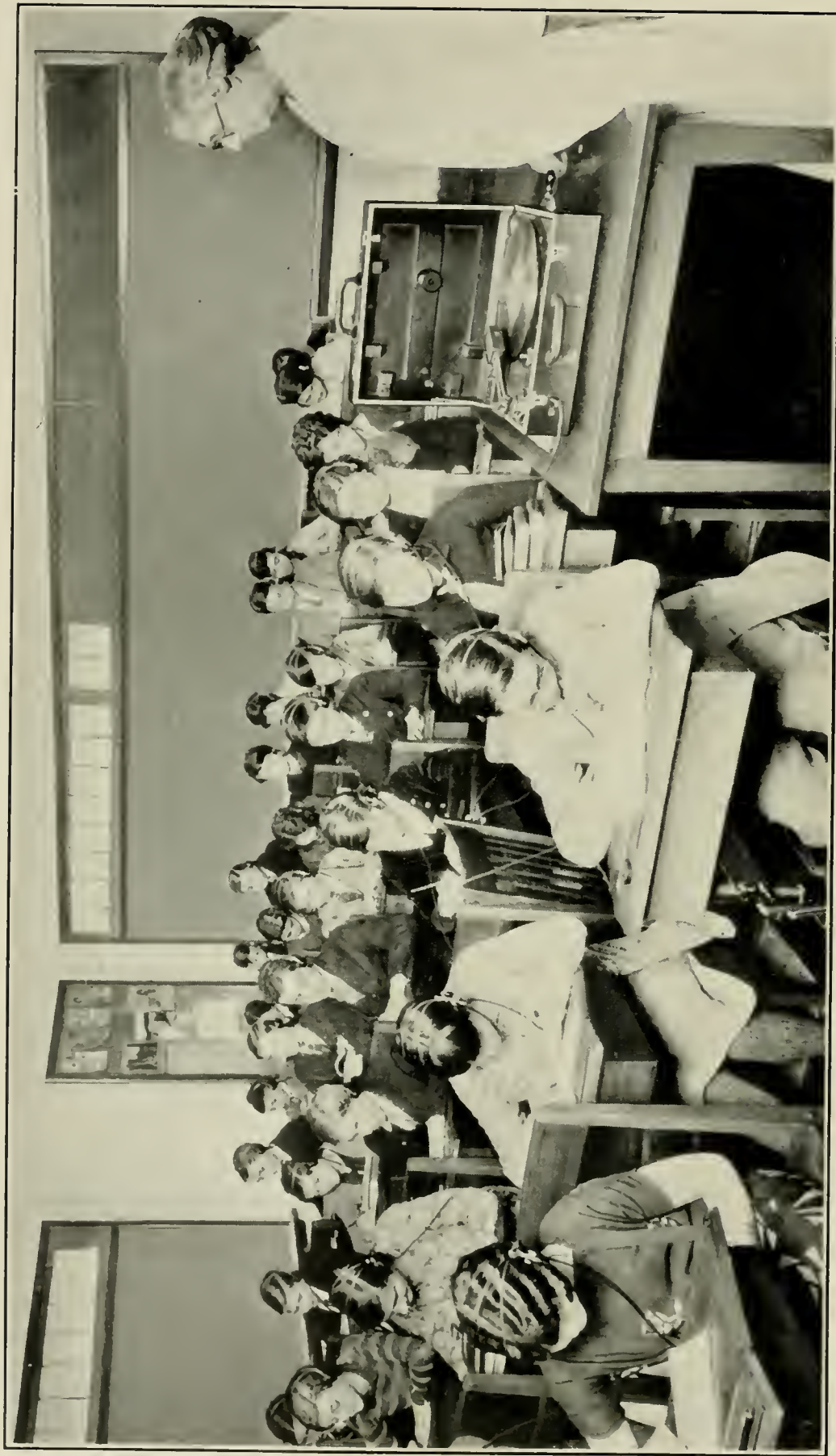
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TESTING THE HEARING OF SCHOOL CHILDREN.
The 4A Audiometer in use in a class room, as described in the article beginning on the opposite page.

Telephone Research and Problems of the Deafened

THE part that telephone research has played in revealing the extent of hearing impairment and in providing aids for the deafened forms an interesting chapter in Bell System achievements. It began more than twenty years ago as a comprehensive study directed toward analyzing and describing speech and hearing just as electrical circuits and telephone instruments are analyzed and described. Many advantages would accrue if the characteristics of the voice and ear could be given consideration in the engineering and design of the telephone.

It soon became evident that the study demanded better instruments than were available and a great deal of work was done toward refining instruments for translating sound waves into electrical form and vice versa. Improvement in instruments opened up new fields of study. Further study created a demand for better instruments and the cycle was repeated. It was only natural that this activity should find application and outlet in fields related to telephony.

THE MEASUREMENT OF HEARING

One of the first problems encountered was that of accurately measuring hearing. The tuning fork and watch tick methods employed by doctors were found to be unsatisfactory for testing people with normal hearing. A method was worked out which involved the use of a special vacuum tube oscillator, attenuator and receiver. Hearing was measured by holding the receiver to the ear and setting the attenuator so that the tone was just audible. The tone was then said to be at the threshold of hearing. From measurements upon a large number of

individuals, normal threshold settings for tones of different pitch were obtained. As a definite intensity level of sound corresponded to a given attenuator setting, the hearing of an individual was measurable in an absolute sense and also with respect to normal.

As the results of this work became generally known a demand for the methods and equipment began coming from hospitals, otologists, and others interested in hearing. To meet these needs the Western Electric Nos. 1A and 2A Audiometers,

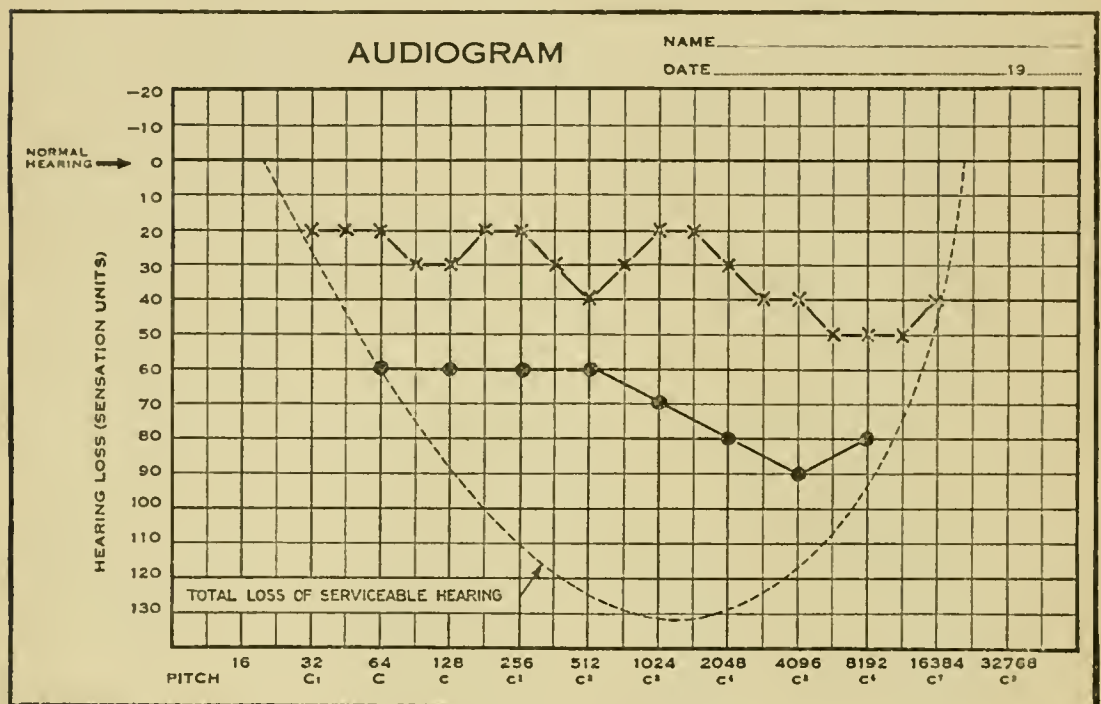


FIG. 2. AN AUDIOGRAM.

instruments which duplicated the laboratory method of testing hearing, were developed. Hearing impairment was expressed as a hearing loss in decibels (db). It is equal to the difference in the normal and deafened threshold intensity levels. A chart showing the hearing loss at various pitches was called an audiogram. Figure 1 shows the Nos. 1A and 2A Audiometers. The audiogram which may be obtained with them is shown in Fig. 2. Normal hearing is shown on the audiogram chart by a horizontal line at zero hearing loss. The dashed line shows

PROBLEMS OF THE DEAFENED

losses which correspond to a total loss of serviceable hearing. This means that the tones cause a sensation of feeling or pain before they can be heard. The hearing losses of an individual with moderate deafening falls between these limits. In the figure, the crosses and circles represent measurements with the Nos. 1A and 2A Audiometers respectively, upon different individuals. The two instruments are functionally alike but cover different pitch ranges.

This method of measuring and representing an individual's hearing is coming into almost universal use by doctors, in clinics and hospitals, and in researches on hearing. Frequently, for diagnostic purposes, both air and bone conduction receivers are used. With the latter receiver the vibrations are communicated to the skull bone in back of the ear, so that the ear drum and ossicles are not involved as directly as in air conduction. Differences between air and bone conduction audiograms are of use in determining whether the losses are due to middle or inner ear defects.

Another form of audiometer, known as Nos. 3A and 5A, enables the average hearing to be measured in the important part of the pitch range. This is done by using a complex tone having overtones throughout the audible range. The No. 3A is battery operated, the No. 5A operates from an electric light outlet. The field for this instrument is in quick and accurate surveys of the hearing of a large number of people. Only a single measurement is necessary and the hearing loss is expressed by a single figure.

THE HEARING OF SCHOOL CHILDREN

Shortly after this research work was initiated, considerable interest developed in this country in the hearing of school children. A number of hard-of-hearing organizations became active advocates of tests and some states and cities passed laws requiring tests in the grade schools. It very soon became evi-

dent that individually testing the hearing of school children was impractical and some sort of a group hearing test was sought. Engineers of Bell Telephone Laboratories were approached since they had developed numerous contacts in this field, and finally a committee was formed under the sponsorship of the American Society for the Hard of Hearing to develop a group hearing test for school children. The Laboratories' member of this committee was Dr. Harvey Fletcher, who not only directed the research work in speech and hearing at the Laboratories but gave unstintingly in energy and time to adapt laboratory results to problems of the hard of hearing.

The form of audiometer shown in the frontispiece was finally evolved for testing groups of school children. It consists of an electrical phonograph which may be connected to as many as forty receivers. On listening to the receivers, the children hear a sequence of numbers which gradually diminish in loudness. They write down the numbers as long as they can hear them. The point at which they fail to hear the numbers is a measure of their hearing.

The test serves as a means of grading the children into groups ranging from normal hearing to seriously deafened. It is particularly useful in catching borderline cases where the impairment is not enough to be noticed at home or in casual classroom contact. The children having impaired hearing are given treatment by an otologist and special provisions are made in their educational program.

The movement to test the hearing of school children has spread very rapidly in recent years, particularly in the cities. It has been estimated that the hearing of more than 1,000,000 children is tested annually, by the use of No. 4A Audiometers. The use of the instrument might be said to be world wide. Hawaii reports tests on their school children and from Cape Town, South Africa, comes a report of tests in English and also in the tongue, Afrikaans, used by the Dutch settlers. In Canada tests are made in English and French.

PROBLEMS OF THE DEAFENED

It is difficult to convey on the printed page the things that are being accomplished by such tests. Case reports abound in instances where the test brought a child to the attention of an otologist in time to correct an incipient infection. Any number of so-called "dull" children have turned out to be "bright" when given special instruction in lip reading and seats near the front of the class.

SOME HEARING CHARACTERISTICS

With accurate methods of measurement available, considerable statistical data on the hearing impairment of people have accumulated. From samplings of the adult population, it has been estimated that the hearing of every tenth person is impaired sufficiently to inconvenience him in ordinary pursuits. Tests on school children show that one out of fifteen is handicapped in classroom work because of temporary or permanent hearing defects.

People seldom hear exactly alike with their two ears. One ear is usually a few decibels more sensitive than the other so that when listening with both ears a person is always certain of using his better ear. Normal hearing for audiometric uses has been based on tests with young people in the age range from 18 to 23 years. The hearing of the average young adult is most acute in the range from 2000 to 3000 cycles. As a matter of fact he has about all the hearing acuity that he can use for it has been estimated that if his hearing were 20 db more acute he would hear the air molecules bombarding his eardrums. Some individuals do almost exceed the average by 20 db, but they are very exceptional.

As one grows older he loses his ability to hear high-pitched tones. The effect of age is shown in Table I. It would appear that when we speak of normal hearing we must keep age in mind as an individual of 60 with normal hearing has a loss of 30 db in the range above 4000 cycles when compared with a

young adult. Hearing in the range below 1000 cycles appears to be affected little, if any, with age.

TABLE I
DB LOSS IN HEARING WITH AGE

Frequency	60 to 1000 Cycles	2000 Cycles	4000 Cycles	8000 Cycles
Ages 20-29 (96 ears).....	0	0	6	6
Ages 30-39 (162 ears).....	0	0	16	11
Ages 40-49 (84 ears).....	0	2	18	16
Ages 50-59 (28 ears).....	0	5	30	32

One's hearing ability varies with the direction from which the sound comes. One hears best when the ear is turned toward the sound source. The effect is most pronounced at the higher frequencies.

When listening in the presence of a background noise one hears less well than in the quiet, a phenomenon known as masking. The effects are somewhat the same as a hearing loss, except that the loss vanishes when the noise is removed. Both forms of audiometers have been used for measuring the masking effect of noise. The noise in an average office in the metropolitan area causes a normal hearing person a loss of 20 to 30 db due to masking. In the presence of such a noise, a person deafened 20 to 30 db would hear as well as an individual of normal hearing.

The No. 2A Audiometer has been used by one experimenter to measure the hearing of chimpanzees. They were found to hear as well as but no better than man. Modifications of the audiometer have been used to test the hearing of cats, guinea pigs, dogs and monkeys, in several physiological laboratories in this country. Although the opinion is often expressed that animals hear better than man, accurate tests of their hearing do not confirm this. This might be expected since man's hearing acuity is near the limit set by the thermal motion of the air molecules.

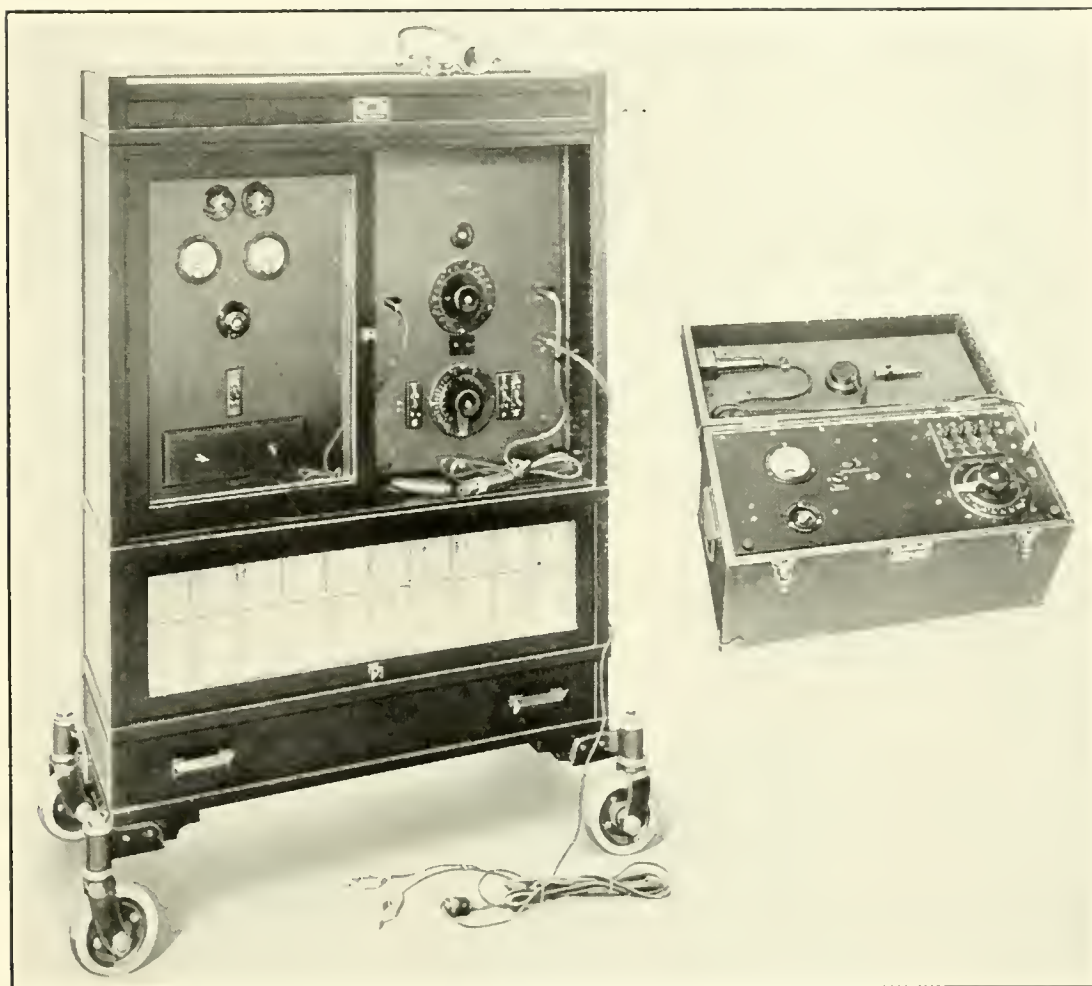


FIG. 1. THE 1A (LEFT) AND 2A AUDIOMETERS.

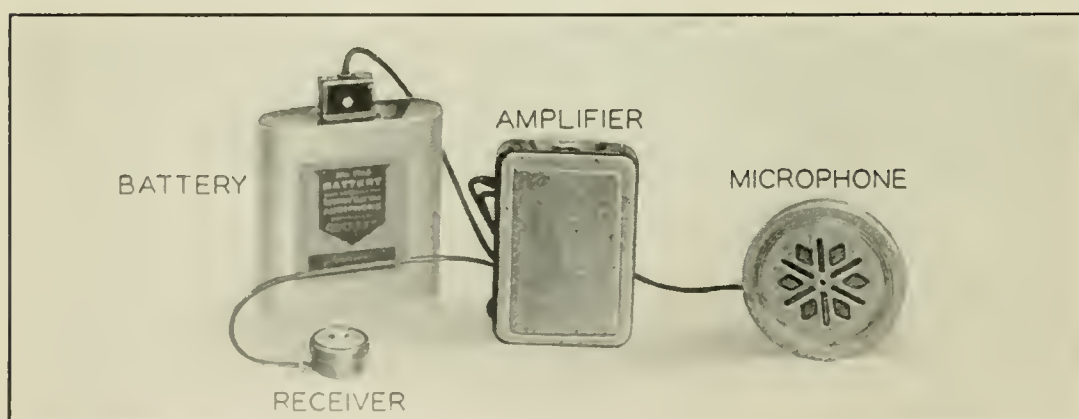
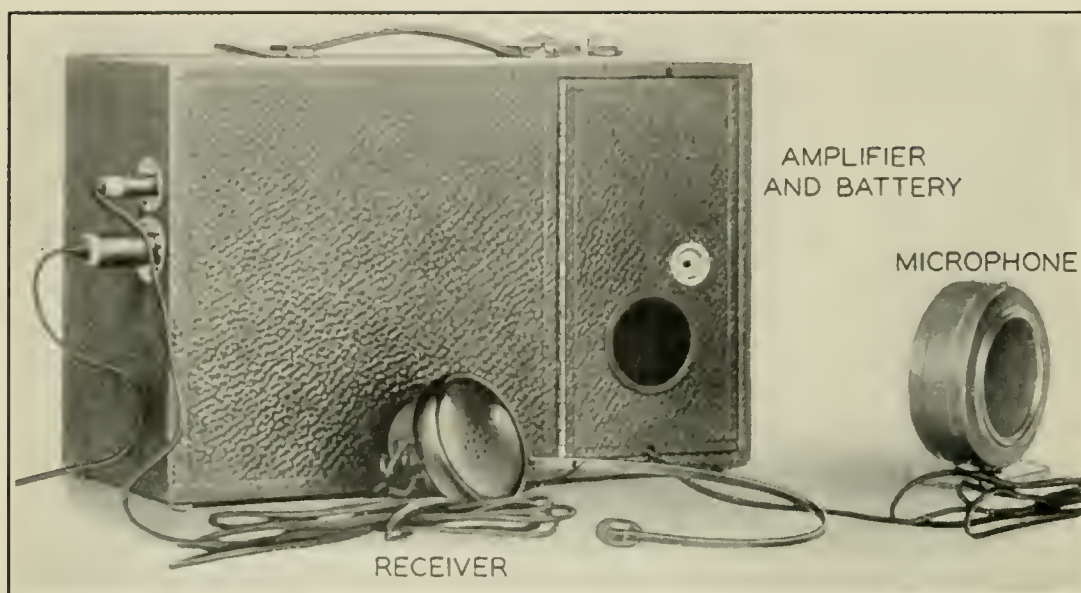


FIG. 3. ABOVE: THE AUDIPHONE OF 1924; BELOW: THE AUDIPHONE OF 1935.

PROBLEMS OF THE DEAFENED

HEARING AIDS FOR THE INDIVIDUAL

It is a common experience among deafened people that they hear better over the telephone than when listening directly to some one speaking. The reason is that the telephone amplifies the sound. Early hearing aids were unable to amplify the sound very much so that they were of use to moderately deaf people only. As improved instruments and telephone devices were developed it was only natural that they should find application in hearing aids. It soon became possible to enlarge any sound almost perfectly and in any amount needed. The device, however, might weigh anything from 30 to 200 pounds, as weight was not an important consideration in laboratory research.

The real story of improvement is told when it is stated that from 1924 to 1935 the weight of the Western Electric Audiphone was reduced from eleven pounds to one pound, eight ounces, and from a volume of 1000 cu. in. to something less than 10 cu. in. It is now possible in many instances to conceal completely the fact that an audiphone is being used. This progress is depicted in Fig. 3.

The older microphones used carbon pellets; the newer ones use a very sensitive granular carbon which was developed from research on microphonic materials. The vacuum tube amplifier was replaced by a carbon button amplifier using the sensitive granular carbon. The development of permalloy made possible the construction of a receiver so small that it can be attached to an ear piece fitted into the ear canal. At the same time light-weight batteries, giving an appreciable amount of service, have become available.

Individuals having a moderate degree of impairment, between 35 and 50 db hearing loss, find the combination of microphone and receiver adequate. When the loss is in the range from 50 to 75 db, a carbon button amplifier must be inserted between the microphone and the receiver to further amplify

the sound. The addition of this amplifier increases the weight only 1.5 ounces. When the hearing loss is greater than 75 db, stock audiphones rarely prove satisfactory. Special provisions must be made, depending on each individual case.

The combination of microphone, receiver and rheostat alone is known as the No. 36 Type Audiphone and when used with an amplifier is called the No. 37 or 38 Type. The bone or air conduction receiver may be used with either type. Which receiver is the better in any particular case depends on the kind of hearing impairment. When the deafness is caused by an obstruction in the middle or outer ear the bone conduction receiver may be better than air conduction. When the deafness arises in the inner ear from nerve defects, the air conduction receiver is usually more satisfactory.

Many users of audiphones have considerable difficulty hearing distant sounds, such as are experienced when attending the theatre or seated around a large table. In the early days this was attributed to defects in the audiphone. Today's audiphones reproduce so perfectly that the contention is no longer valid, although the difficulty still persists. The difficulty that the audiphone user has is similar to that experienced by a person with normal hearing when listening with one ear closed. Try this at the theatre some time and note the confusion that appears in the sound. The difficulty may be overcome by using an audiphone for each ear, or binaural hearing as it is called. This enables one to hear sounds in their proper spatial relationships, and much of the confusion in distant sounds is avoided.

TELEPHONE FACILITIES

For cases of impairment, where the ordinary telephone facilities are not adequate, special provisions are obtainable. Sometimes it is a case of being unable to hear the telephone bell. Lower pitched and more powerful bells and gongs and visual signals are available. When the speech cannot be heard

PROBLEMS OF THE DEAFENED

a special amplifier can be connected into the telephone set. A volume control is provided for the deafened subscriber's use and a switch to remove the amplifier for the normal hearing subscriber.

HEARING AIDS FOR GROUPS

Hearing aids for installation in churches, theatres and public halls so that a number of persons may listen are also available. These generally take the form of a number of outlets to which either air or bone conduction receivers may be attached. The outlets are connected to a powerful vacuum tube amplifier which in turn is connected to a microphone near the pulpit or stage. This type of aid is generally preferable to listening with an audiphone directly, as the microphone is much nearer the speaker.

NEWER CONCEPTS

Research work on hearing is still in progress. One of the important attributes of a sound is its loudness. Methods of measuring loudness have been worked out and have found application in the field of noise measurement. This field has been the subject of study by a committee of the American Standards Association, and many of the methods and techniques worked out in hearing studies have been incorporated in proposed standards for noise measurement.

From loudness level measurements with pure tones of different pitch, contour lines of equal loudness have been mapped out for the entire pitch and intensity range of the normal ear, i.e. the range included between the top and dotted lines on the audiogram chart of Fig. 2. Masking measurements with pure tones indicate how such sounds stimulate the hearing mechanism. The work indicates that when a tone enters the ear it stimulates a certain area in the inner ear. The nerves in the stimulated area conduct impulses to a corresponding area in the brain. The loudness of the sound is correlated with the number of nerve fibres conducting impulses. Since masking

is a measure of the amount of stimulation at various areas in the inner ear, it would be expected that an integration of a masking curve would give the total number of conducting nerve fibres and hence of the loudness of the sound. This has been found to be the case for a number of sounds investigated.

Nerve deafness is supposed to arise from the atrophy of the nerve fibres supplying the various areas of the ear, so that when an area is stimulated there will be less conduction to the brain than in a normal ear. The picture of loudness described above indicates that this loss in conduction will be much more noticeable for faint sounds than for loud sounds. In the latter case there are so many conducting nerves that the loss of a few will be unnoticed. In other words, a person having nerve deafness may show an appreciable hearing loss when tested with sounds that are just audible, but when tested with sounds 30 or more db above audibility will hear in a perfectly normal manner. Obstructive deafness, on the other hand, results in the same hearing loss for faint as for loud sounds. The usefulness of employing loud as well as faint tones in hearing tests, as a means of diagnosing types of deafness, is a subject that needs further study. The complete mapping of the deafened hearing throughout the audible pitch and intensity range may give a clearer insight into the nature of the impairment and the method of relief.

JOHN C. STEINBERG

Communications and Police Protection

EVERY invention, while adding to the comfort or welfare of society, introduces its own peculiar problems. We think of rapid transportation, for example, as a boon to mankind. Primarily, it is; but, at the same time, those who refuse to conform to society's rules of conduct make of it an aid to the law-breaker. The modern criminal employs the speedboat, the airplane, especially the fast motor-car and our hard roads as means to accomplish his own ends. He has greatly shortened the time it takes him to escape from the scene of a crime.

While speed has been added to the kit of the up-to-date criminal, science, fortunately, has been able to answer this speed with more speed. Invention keeps a pace ahead of the enemies of society. The evil-doer knows that, whereas a few years ago half an hour or longer might elapse before a policeman put in his appearance, it is now likely to be a matter of only a few minutes before a dozen or more officers of the law reach the scene. Escape time has been greatly reduced. And this diminution has been brought about chiefly by agencies of communication—the telephone, the teletypewriter and the radio, along with improved techniques for their application to law enforcement.

With time having become so important an element in the apprehension of criminals, it is essential that the public cooperate with police forces in order to secure the maximum of protection. None is more aware of this fact than the police official. Constantly, police departments urge citizens not to delay in reporting to headquarters not only crimes which are witnessed but suspicious persons or circumstances. The New York City Police Department recently distributed 100,000

posters, appealing to the public to "Phone the Police." The faster a report goes in to headquarters, the faster police departments can swing into action, thus cutting down "escape time" and making an arrest more probable.

In general, it may be said that there are three types of police communication. First, there is the telephone. With its 87,000,000 miles of wire, its army of trained, alert workers motivated by the traditional Spirit of Service, the telephone system offers the means of making the quickest possible contact between the public and the police. When you say to the operator "I want a Policeman" you have taken the first necessary step in law enforcement.

To the police forces the telephone is indispensable. Not only do their switchboards handle the many calls from the public but countless messages from one police official to another go over the board.

As the police go into action in the war against crime, not only the telephone but the teletypewriter and the radio come into play. The telephone, the teletypewriter and radio, all three, are swift, practical and dependable; but, the teletypewriter, with its printed record, its duplicate copies, its ability to receive messages at unattended stations, its secrecy and its power to communicate simultaneously with many points over a wide area, offers features of special value to law enforcement bodies, and, accordingly, forms the basic system in a modern police communication network. For establishing contact over a limited area between headquarters and mobile police units, such as automobiles, radio is proving of increasingly great value. Captain Albert B. Moore, Inspector of the New York State Police and Director of the New York State Police School, who is in command of the state police teletypewriter and radio systems, emphasizing the value of these services in a recent talk in Richmond, Va., said:

"Police information to be of value must of necessity be accurate. Any errors in transmission might result in serious com-

plications. The accuracy must be supplemented by rapidity of transmission, and the rapidity of transmission must place the information at all points within a given area simultaneously in order to be of value. Criminals leaving the scene of their operations may depart in one specific direction only to change their course, and perhaps double on their tracks. It is therefore obvious that all directions of the compass must be considered in the hunt for these malefactors. . . .

"Many times I have been asked concerning the value of radio for police work. I believe it is valuable and has its place in any well organized communication system. Radio presents possibilities for limited areas, but in New York state it would be practically impossible to have one radio system capable of reaching throughout the entire state. There are several municipal police stations and these are having highly successful results. However in a broad area, such as New York [state], radio must of necessity be supplemental to teletypewriter."

August Vollmer, criminologist and former president of the International Association of Chiefs of Police, writing (with Alfred E. Parker) on "Crime and the State Police," says of teletypewriter systems and other modern instruments in use by the police: "It is this modern equipment in well-trained hands that often enables the State Police to be so effective against modern criminals. Perhaps this is nowhere so evident as in the use of quick means of communication. . . . The teletypewriter system as installed by the New York State Police is an outstanding achievement in State Police communication."

The best equipped police forces today employ to advantage all three forms of communication.

TELETYPEWRITER SERVICE

Simply expressed, a teletypewriter is an electrical device for typewriting by wire. Perfected in 1915 (when it was known as printing telegraph equipment) it has been continuously improved. Today, including machines for both private lines and

switched service, some 1,200 teletypewriter stations provided exclusively for police purposes are actively in use in the United States. This number is rapidly increasing.

Since 1927, when various municipalities in Connecticut began to use a private line teletypewriter system, the importance of the device in police communication systems has steadily grown. On December 23, 1929, the first state police teletypewriter system was inaugurated by Pennsylvania. On October 1, 1930, New Jersey inaugurated a state-wide system, and provided for the first interstate connection, which was between New York City, New Jersey and Pennsylvania. In 1931 as a demonstration there was established by private wire a police teletypewriter hook-up of 7,000 miles, involving twelve states, a Canadian province and fifteen cities scattered from New York to the Pacific Coast. About a year and a half ago, the state of Connecticut completely revamped its system and established it upon a state basis. In the meantime, a cooperative movement among the states in the east had been growing. The need for rapid communication from one state system to another had become apparent. Out of this need there developed an eight state regional system which furnishes teletypewriter coverage to the states of New Jersey, Pennsylvania, New York, Connecticut, Massachusetts and Rhode Island with connections to Delaware and Ohio.

It is easy to see how lessened has become the chance for the criminal to escape in this large area, for it is possible over the eight state hook-up for a state to flash almost simultaneously a report on a crime to each of its teletypewriter stations and to a police point in a neighboring state, where the report may be re-transmitted to other cities and eventually to other states. Full coverage of the eight states for a police alarm is obtained in this way in less than 20 minutes. Furthermore, plans are under consideration for the establishment of teletypewriter systems in a number of adjoining states. When these are connected, as planned, with the existing regional system, there will be no

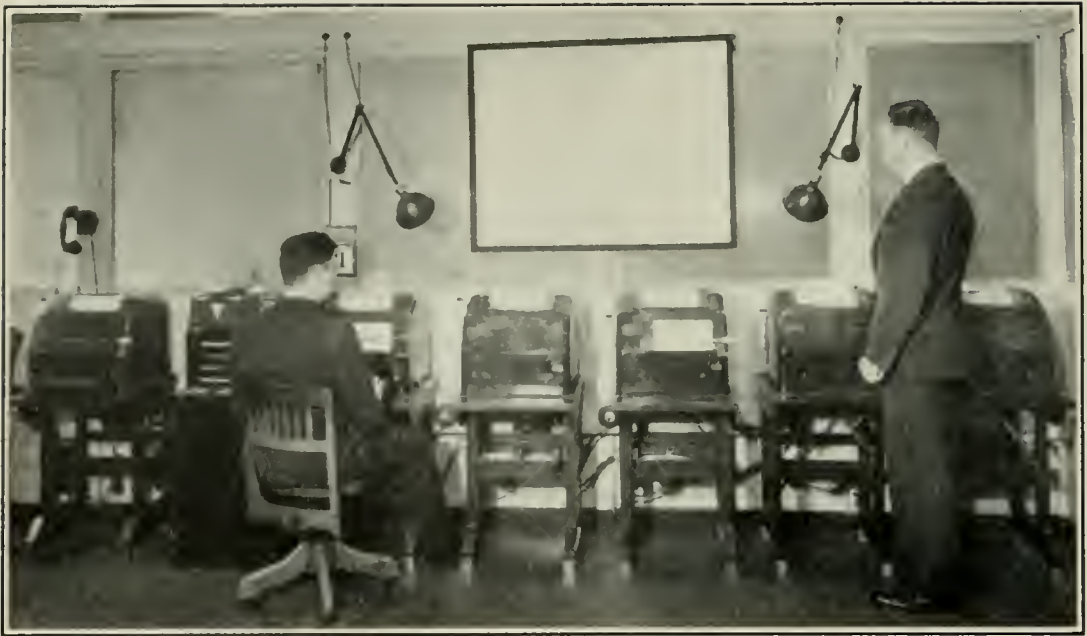


THE TELETYPEWRITER DIVISION OF THE COMMUNICATIONS SECTION OF THE FEDERAL BUREAU OF INVESTIGATION, UNITED STATES DEPARTMENT OF JUSTICE, WASHINGTON, D. C.

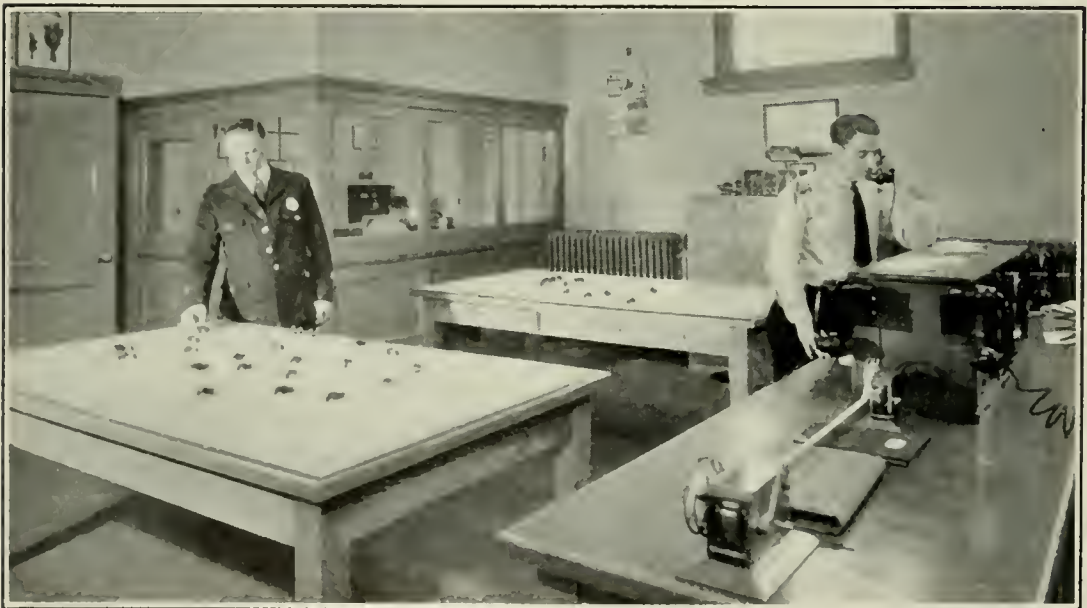


N. Y. DAILY NEWS PHOTO

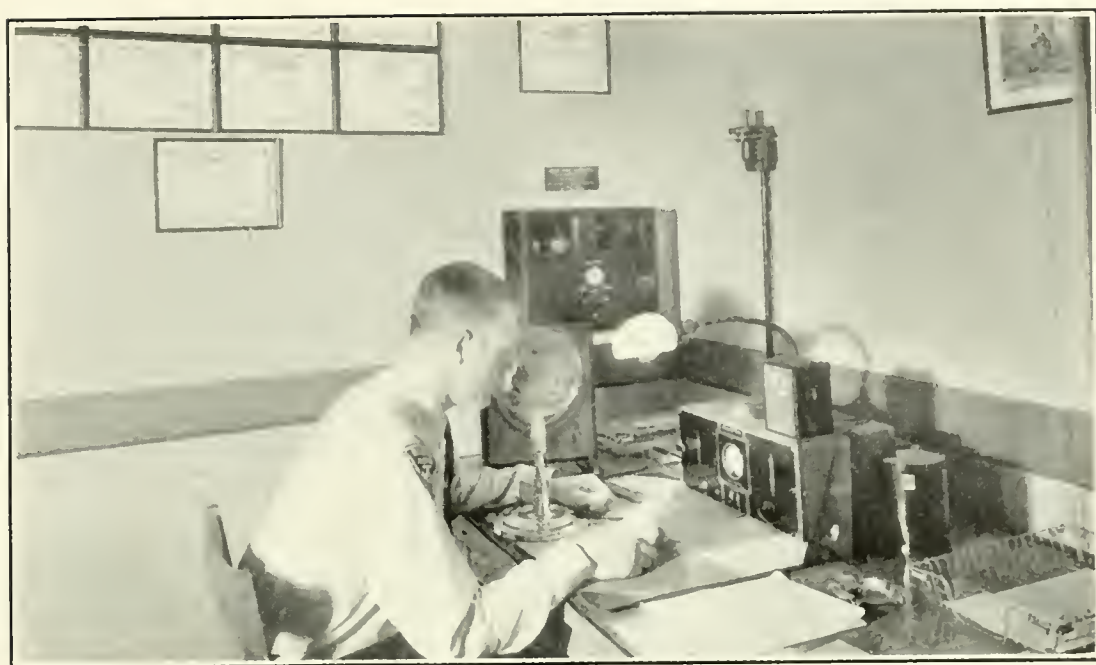
CAPTAIN ALBERT B. MOORE, COMMUNICATIONS OFFICER OF THE NEW YORK STATE POLICE, ADDRESSING A CONFERENCE OF POLICE OFFICIALS ON TELETYPEWRITER TECHNIQUES. LIEUT. KINSEY OF THE OHIO STATE HIGHWAY PATROL IS PRESIDING.



THE NEWARK ZONE HEADQUARTERS OF THE NEW JERSEY STATE-WIDE POLICE
TELETYPEWRITER SYSTEM.



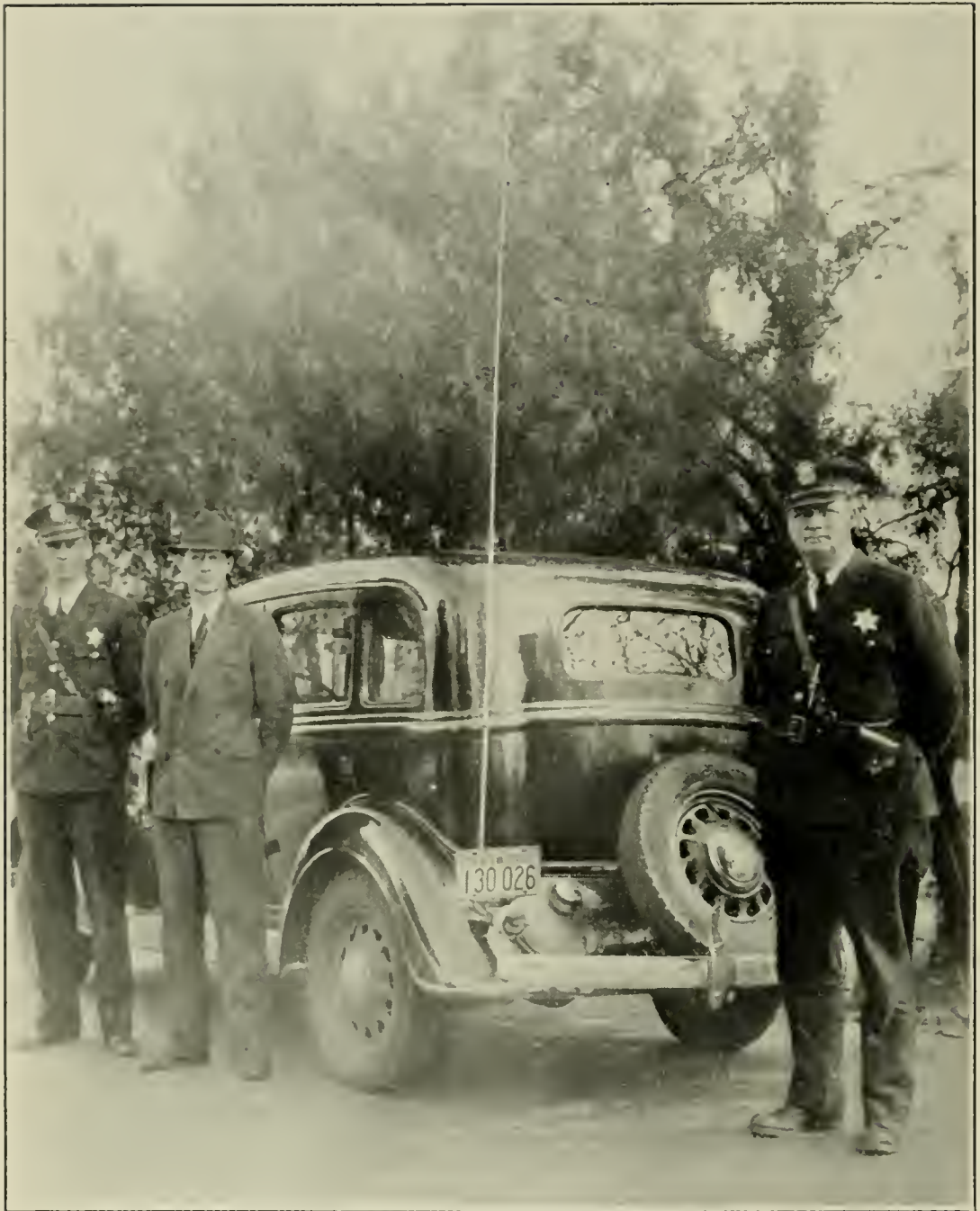
THE RADIO ROOM AT POLICE HEADQUARTERS, NEWARK, N. J. THE OFFICER AT THE
RIGHT IS RECEIVING A TELEPHONE CALL WHICH REQUIRES THE DISPATCHING OF A
RADIO PATROL CAR, THE OFFICER AT THE LEFT IS SELECTING THE CAR, AND THE AN-
NOUNCER IN THE BOOTH AT THE REAR IS PUTTING THE CALL ON THE AIR.



THE RADIO ANNOUNCER AT NEWARK, N. J., POLICE HEADQUARTERS IS TRANSMITTING AN ALARM OVER THE ULTRA-HIGH-FREQUENCY SYSTEM.



NEWARK POLICE DEMONSTRATING TWO-WAY RADIO OVER THE ULTRA-HIGH-FREQUENCY CHANNEL.



AN EVANSVILLE, IND., POLICE PATROL CAR EQUIPPED WITH THE TWO-WAY ULTRA-HIGH-FREQUENCY RADIO SYSTEM, SHOWING THE TRANSMITTING ANTENNA AT THE REAR OF THE CAR.

longer merely an extensive eastern teletypewriter network but the beginning of a truly national system.

The municipal teletypewriter system may vary from a few sending and receiving machines to the 136 in New York City. The teletypewriter system of the Police Department of the City of New York is, naturally, complex. The greater city is divided into five boroughs—Manhattan, Brooklyn, Bronx, Queens and Richmond. For each borough there is a separate police command with a headquarters office. In each borough headquarters there is a switchboard with tie-lines which permits two-way service between general police headquarters in Manhattan and the other four boroughs. Associated with the switchboards are a total of 136 teletypewriters. This flexible system provides that messages may be sent to any single teletypewriter machine, to a group of machines or to all machines connected with the switchboards; it furnishes two-way communication between general headquarters and the other four borough headquarters, as well as one-way communication between each borough headquarters and each precinct in the borough. Two classes of information are transmitted over the system: first, that of general importance which is transmitted by general headquarters to the other boroughs where it is widely distributed when the precincts are involved; second, that which concerns a particular borough. The information thus transmitted originates from communications received at headquarters from precinct, division or district commands, or from reports from the public.

A good example of a county system is that which serves the police of Nassau County. It is not only useful in the work of protecting all sections of the townships not included within the limits of incorporated villages (in certain instances incorporated villages are patrolled also) but, as it is tied in directly with the New York City police teletypewriter system and the New York State system, it is one unit in a regional network.

The county police department is divided into six precincts

with headquarters at Mineola. The system consists of a 20-line switchboard at Mineola from which two-way circuits are extended to each precinct headquarters, terminating in receiving and sending instruments. The switchboard is so arranged that the operator may send or receive messages to or from any station connected with the switchboard. Messages may also be sent simultaneously to a selected group of stations or to all stations in the system.

With the New York City system, the Nassau County system is connected by two one-way circuits. The circuit from Mineola to New York City terminates in a receiving only machine at Manhattan headquarters, while a circuit from Manhattan headquarters terminates in a receiving only instrument at Mineola.

These municipal and county systems are, generally, connected with each other and with the state systems and are tied in by direct teletypewriter circuits with the systems of neighboring states. In many instances, they are supplemented by strategically located police radio stations.

The state of New York dispatches over its teletypewriter system more than 250,000 communications each year. Of these, about fifty per cent are concerned with automobile registrations and requests for data, stolen cars, recovered cars, hit and run drivers and emergency notices to automobilists. Another ten per cent is accounted for by reports on missing persons, with about forty per cent devoted to the more spectacular misdeeds and routine administrative business. The dramatic crime is relatively rare. Its scarcity may be due somewhat to the preventive factor present in modern police communication systems. Police officials are convinced that the knowledge of the existence of modern communication equipment in a given area acts as a crime deterrent.

The teletypewriter is admirably suited to the handling of that vast amount of police business of which the public does not hear. In many cases, an instrument is stationed in the

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state's motor vehicle bureau so that data needed by the police can be obtained promptly and reported back.

Most police teletypewriter systems are set up on a private line basis. However, a certain limited use of Teletypewriter Exchange Service has developed since 1931 when the latter service was introduced.

One of the most interesting of recent installations is that of the Federal Bureau of Investigation of the U. S. Department of Justice. Teletypewriter Exchange Service (familiarly known as TWX) was placed in operation in 1935 for communication between the Bureau's Washington headquarters and its 36 field offices located in other strategic cities throughout the country. There are four machines in the headquarters office at Washington, two each in the New York, Chicago and Philadelphia offices, and one each in the remaining field offices.

When the Bureau's Director, J. Edgar Hoover, or a member of his staff in Washington wants to communicate with the field in which are operating 500 specially trained men—the famous "G-men"—the procedure is somewhat as follows:

In the communications section of the Bureau in Washington, one of the men assigned to the work throws a switch on one of the machines. When the TWX operator indicates that she is ready, the Bureau operator types, let us say, Denver 0711. When, a few moments later, a bell rings in the Denver office there will be some one on duty to handle the call, for all the field offices, in charge of special agents, are open day and night. The field operator establishes connection and the Denver machine is ready to reproduce the message typed in Washington.

Again, Washington may want to be in touch with all 36 field offices at one time. There may even be additional temporary offices with which headquarters wants to communicate while addressing the field. Swiftly, Bell System operators go into action. Following a carefully formulated plan, they set up a conference TWX circuit linking the Washington office, over

hundreds of miles of wire, with every field office. In less than half an hour, every teletypewriter in every field office is simultaneously clicking off the Washington report. The communication may have to do with a matter of administrative routine, with a robbery or a kidnaping, with any one of hundreds of crimes to which the G-men may be assigned.

The Bureau, of course, makes extensive use of the long distance telephone. Its speed, privacy and suitability to personal, two-way discussion commends it. When, in addition to speed, privacy and the two-way channel, it is desirable that the message be transmitted in written form, TWX service efficiently meets the need.

The following actual case is a good example not only of cooperation between different police organizations but of the value of the teletypewriter in spreading information quickly over a wide territory.

Four men broke into a jewelry shop in Beacon, N. Y. Local police surprised the thieves and managed to catch one. The other three escaped in an automobile, taking the road for New York. Immediately a message was dispatched over the state teletypewriter system by the State Police at Fishkill. The robbers were sighted once again on their dash southward and an added alarm was teletyped concerning them. By the time the fleeing thieves reached Yonkers, practically every peace officer in the county and every police officer in New York City was on the lookout for them, having been warned by teletypewriter messages relayed by radio to patrol cars or by telephone to call-boxes.

Charles Smith, Westchester County Parkways patrolman, encountered the robbers in Yonkers. He waved them to a stop but they answered by firing their revolvers at him. Smith gave chase on his motorcycle and forced the speeding car into a ditch.

A hand to hand combat ensued. Smith caught one of the

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trio, but the other two broke away and, commandeering a taxi-cab, started once more for New York.

The taxi-cab was halted finally by New York City police. Once more there was an exchange of revolver shots. This time the police killed both the bandits.

Another actual case, in which telephone, teletypewriter and radio dove-tailed, is that of Robert J. Mahoney who shot State Trooper George Doring in Sudbury, Mass. Five hours later, Mahoney was dead in Leicester, Mass. Trooper James H. O'Neill had brought him down.

Trooper Doring had called on Mahoney to halt. Mahoney replied by firing at him and wounding him. The gunman, a girl beside him in his car, roared down the road toward Worcester.

"Within five minutes after the shooting of the policeman," said the *Worcester Telegram*, "the Framingham barracks of the state police had established contact with troopers on patrol. Two men were assigned to watch the Post road and question all persons answering the description given. One trooper was posted near the scene of the attack. . . . Garages and call stations were notified to flag all the passing troopers and to direct them to call in immediately.

"Automobiles equipped with radio receiving sets were immediately contacted as they cruised through the Lake Boone region. Those troopers learned of the crime within ten minutes of its occurrence.

"The teletype switch was thrown open and a white light glowed over 'Framingham' on the switchboard in the State House headquarters of the State police patrol. An operator pulled a switch on the teletype machine and a policeman in the Framingham barracks began his story. The story was in cold type almost as soon as one could tell it. The operators threw down the plugs to Holden, Middleboro and Northampton. Over the wires to these stations went the news of the shooting.

"At Framingham the telephones rang loudly as the troopers called in from garages and call stations. Nine men were ordered to Worcester to find the missing bandit and bring him back. They started for Worcester while 23 men whirled out of the substations at Reading, Concord, Topsfield and Wrentham. . . . In the meantime at Holden the teletype was grinding out its story."

From the north, east, west and south the troopers came, called by the teletypewriter, telephone and radio. Finally, a hundred men were involved in the hunt. The bandit was bottled up somewhere near Worcester. Every avenue of escape was closed. It was only a matter of time before Mahoney was caught.

At Spencer the engulfing waves of troopers met. Mahoney was surrounded. He wrecked his car against a stone wall, injuring his girl companion, and took to the woods, alone and on foot. He ducked and dodged. He tried to steal a truck and failed. From another truck he got a short ride. At Leicester, he was on foot again, crawling through back-yards. He climbed the fence at the Leicester Tavern. Trooper O'Neill of Holden saw him. He called to him, then fired. Mahoney toppled. O'Neill went after him. Lieutenant Shimkus and Sergeant Sullivan ran up. Mahoney had crawled to a cellar, leaving a trail of blood. Shimkus called on him to surrender. The bandit, his voice choking, refused and fired at the officer. The Lieutenant rushed upon him and disarmed him. Mahoney lost consciousness and died half an hour later.

In the words of the *Worcester Telegram*: "A bullet killed him, but radio and teletype and telephone had already doomed him."

Since 1921, when the Detroit Police Department began its experiments, an increasing number of law enforcement units have been making use of radio. At the close of 1935 there were in operation more than 60 city, county and state Western Electric Police Radio Systems, as well as others manufactured by other companies, all of them getting cars full of police officers to scenes of crime within two or three minutes after the report had been received at headquarters. Police radio is giving added protection to 35 million people.

TWO-WAY POLICE RADIO

In the spring of the same year, Bell System engineers contributed to the war against crime one more important weapon. This is a Two-Way Police Radio, a great advantage to peace officers in a limited area. With this equipment, the motor patrolman not only receives alarms but he may acknowledge them, request further instructions, report crimes or suspicious persons or circumstances, may inform headquarters of his position and progress on an assignment—all, without leaving the wheel of his car.

The first installation of the new system was in Evansville, Indiana. Westfield, N. J., Morristown, N. J., Manchester, N. H., Elgin, Ill., Wheeling, W. Va., and Nashville, Tenn., are scheduled to have two-way equipment in operation in the near future.

Statistics covering five months of operation in Evansville are startling. They reveal a decrease in crimes of 17 per cent and an increase in arrests of 60 per cent, following the introduction first of one-way and later of two-way police radio.

The two-way system operates on ultra-high frequencies in the band of 30–42 megacycles. In addition to a transmitter at headquarters and receivers in the patrol cars, it includes specially designed transmitters for the cars and a receiver at headquarters. The car transmitters, weighing only 20 pounds, are only 11 by 7 by 6½ inches in size and yet are held to within .025 of an assigned frequency by a new type of crystal with a low temperature coefficient.

A flexible steel rod, projecting slightly above the top of the car, acts as a vertical antenna which transmits as well as receives. On the dashboard hangs a telephone, much like the familiar hand-set, and the patrolman's voice speaking through it operates relays which put the car transmitter on the air. These relays are so timed that they do not switch off during intervals between words but do so after the brief pause which

shows that the speaker has finished. The car receiver then automatically goes into operation and is ready to pick up messages from headquarters.

Most police radios operate on a medium frequency band, roughly from 1,600 to 1,700 kilocycles and from 2,300 to 2,500 kilocycles. With an eye to the crowding that might take place within that narrow range, the Federal Communications Commission recently assigned to police work experimentally, an additional band which ranges from 30,000 to 42,000 kilocycles. The system of the Police Department of the City of Newark, N. J., among the most up-to-date one-way installations in present use, operates in the new high frequency band on 30,100 kilocycles.

For municipal stations, there are certain advantages in ultra-high frequency operation. Freedom from atmospheric disturbances is one. No static, or thunderstorms will trouble the ears of the motor patrolmen.

As wave length determines antenna length, Newark is able to employ a short section on the 100 foot flag pole atop the city's tallest building, the National Newark & Essex Bank Building. Conversion to two-way service would, should authorities determine upon it, be very simple as the car transmitters could operate on the wave length which the station now uses. Short waves do not carry great distances from such stations. For State Police work two-way radio, because of limited range, is not now developed so as to be practical. The limited range has an advantage, however, in that a city as close to Newark as Albany probably could use the same wave length without overlapping. However, as the separation between ultra-high frequency channels is very narrow all apparatus, to perform successfully, must be of great refinement, stability, selectivity and reliability.

Put into service on October 3, 1934, by Director of Public Safety Michael P. Duffy, the radio branch of the Newark Police Department has made enviable records not only in efficient

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Out**

COMMUNICATIONS AND POLICE PROTECTION

law enforcement but in overhead cost reduction. Said the *Newark Ledger* recently:

"The radio division has made 849 arrests, extinguished 55 fires, saved more than 40 lives and recovered stolen property valued at \$115,002. . . .

"In 1931 there were 110 more men in the police department than there are today. Radio made it unnecessary to replace them upon retirement. Figuring on a base pay of \$2,300, saving of their salaries means more than \$250,000 in the annual running expense of the police division.

"In addition Duffy was able, due to the wide scope that one car can handle, to abandon four police precincts.

"Several months ago, the director shut down the Fifth, Sixth, Seventh and Eighth Precinct Station houses. 'These properties will be put on sale when the real estate market improves,' Duffy said.

"That means the property will once more become taxable and will show in the ratables.'

"Case records kept by the radio division tell an interesting, important tale.

"On Nov. 8 at 1:44 P.M., car 42 was sent to 52 Littleton Avenue, where a thief was ransacking the premises. The house was covered front and rear and a radio patrolman entered the front door and arrested the burglar. At 1:48 P.M., a patrol wagon was summoned to take the prisoner. The man has a criminal record.'

"On Dec. 11 at 10:15 A.M., car 52 noticed smoke coming from a house on North Seventh St. A patrolman entered the building and brought a 90-year-old man and an infant to the street in safety. In doing so he was overcome by smoke and received treatment at City Hospital.'

"On Dec. 6 at 11:43 P.M., two cars were sent to a Sumner Avenue building where a woman was about to commit suicide by leaping from the roof. Car 22 arrived at 11:45 P.M. and took her from the roof in safety.'

"On Nov. 18, radio car 52 noticed auto parked near Bloomfield city line. Two men were in car. Officers investigated and found car contained sawed-off shotgun, an automatic revolver, and burglar tools. The men admitted a plan to hold up a gas station.'

"These are only a few of the tasks the radio men have performed successfully."

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COMMUNICATIONS AND POLICE PROTECTION

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A review of recent developments in methods of exchanging intelligence among law enforcement units, indicates that to

the constant war against crime the art of communication has made two most valuable contributions. First, through virtually universal telephone service it enables the public quickly to give an alarm. Second, through teletypewriter and radio it allows the authorities to take rapid action upon the receipt of the alarm and, if need be, to spread information far and wide with little or no loss of time.

To the long arm of the law has been added a voice. And that voice, whether it be the 24-hour a day chattering of the teletypewriter, the staccato bark of the radio or the familiar ring of the telephone, is daily putting fear into the hearts of criminals and making life safer for the public.

STERLING PATTERSON

Engineering the Telephone Fleet

WITH a fleet of some 17,000 cars and trucks in service throughout the country, the Bell System requires annually a large number of motor vehicles for replacements alone. While full advantage is taken of advances in design which are developed within the automotive industry, the great majority of bodies and associated equipment for the vehicles purchased are designed by Bell System engineers. In this large portion of the fleet are the vehicles ranging in capacities from one-half ton to 10 tons which transport workmen as incidental to their general functions of gang construction and maintenance work.

As the first step in providing proper vehicles for telephone work in either the commercially available or specialized group, chassis are selected for each individual kind of service, with regard to carrying capacity, performance characteristics, and size. In addition, consideration is given to the first cost and the economy of operation of the chassis as well as service facilities available. This carefully selected type of chassis, which is ordinarily built in quantity and thus can be secured at a reasonable price, is the foundation for the proposed unit of the telephone fleet. A satisfactory type of chassis is usually available in more than one make, so that there is provided a choice in various parts of the country to meet local conditions of service.

For the cases where special body equipment is required, there is at the present time a sufficient standardization of chassis dimensions so that one design of body can be made which can be adapted, with minor modifications, to several makes of chassis.

The vehicle manufacturers generally have developed cabs which fit their chassis and are suitable for use with practically

any type of body that it may be desired to mount back of them. These cabs also are produced in quantity at very reasonable prices.

Having secured the chassis and cab suitable for the job in question, a specially adapted body, together with accessory power devices and other equipment applicable to the particular type of work, are added to provide the complete telephone vehicle. Depending upon the class of work, the accessory equipment may include such items as a power winch, pole derrick, collapsible power reel, power pump, air compressor, towing hook, etc. It is the purpose of this paper to discuss some of the factors entering into the design of various types of telephone truck bodies. The accessory power equipment will not be discussed in detail.

In the work of the telephone engineers, first consideration is always given to factors of utility, cost, maintenance, and safety, while adding, in so far as practicable, features which have to do more with appearance. Much has been accomplished by the manufacturers in providing lower chassis designs, with greatly improved radiator, lamp, hood, cowl, and cab appearance, as compared with those available a few years ago. While holding fast to maximum utility, the appearance of the telephone body designs has kept in step with the rapid improvements which have been made throughout the automotive industry.

One of the generally used units in telephone service is the one-half-ton installation car, in the "LI" classification, which serves the installers and their helpers in connecting, moving, and removing the telephone sets and the associated wire to and upon the subscribers' premises. At the present rate of about 1,300 LI bodies purchased a year, the production has reached sufficient quantities to warrant the use of such manufacturing equipment as to result in low cost, high quality, and uniformity in the units.

For these and most of the other bodies which are fabricated from sheet metal, a type of sheet is used which is protected

from rusting by very thin smooth coats of zinc forming what is termed a galvanized surface. With such material, even though the paint on the outside of the body is ruptured, there is very little tendency for rust to form and undermine the adjacent painted surfaces. Thus the galvanized material improves the appearance and increases the life of the body.

The roof, drawers, doors and various other parts of the body are formed in large presses with suitable dies and jigs, to expedite the work and to insure good fits between fabricated parts as well as between drawers and their guides. Throughout the construction, spot welding is used very generally, with only a small number of rivets at strategic locations.

Strong ladder brackets are provided for use at the side of the LI body to carry the extension ladders which are ordinarily used by installers. Quick-acting fasteners are used to secure the ladders in place while in transit.

Practically every item of equipment, both tools and materials, which an installer ordinarily uses is assigned its properly located compartment in the body. Provision is made for carrying all sizes and types of telephone instruments and subscriber sets in such a manner that they are easily placed in and removed from the body and so that they will not be damaged in transportation even though in isolated cases particular instruments may be carried several days. The materials are so arranged in the body that those which are associated are grouped together and those most frequently used are most readily accessible. Some idea of the amount of detail represented in the design of the body is obtained when it is realized that in this one body there are incorporated about 125 drawer spaces, racks, tool holders, and compartments. All of the items of equipment are carried, protected from the weather, in these conveniently accessible compartments, in a body which is quite low in price for the facilities provided. The entire unit is painted in the standard telephone color, providing a very presentable type of vehicle for the use of the thousands of Bell

System installers in their very large number of customer contacts.

There are other types of bodies having somewhat the same general appearance as the LI installation body just mentioned, but which are necessarily entirely different in compartment space and interior design to adapt them to other classes of service. One such unit is known as the "Type SL" body, for use of section linemen and installer-repairmen. In addition to the suitable compartment spaces within the body, this unit has a strongly built roof with sides and a front rail and also rope loops, providing facilities for carrying brush during tree trimming work, or bulky materials which might be required in connection with repair work. Also, a unit of this type equipped with a light towing hook at the rear can be used where desired in isolated territories to haul light trailers carrying poles or coils of wire.

Yet another vehicle of the general type of the LI unit is the splicer-repairman body, which is known as the "CS" unit. Because of the volume of tools and equipment required by this type of gang, the CS body is larger than either of the two previously mentioned. The weight of materials and tools, such as tanks of nitrogen gas and lead sleeves, which have to be carried, is so great that in order to keep within the normal carrying capacity of light commercial chassis, it has been found desirable to fabricate the body and its equipment from a very light aluminum alloy. By so doing, several hundred pounds in weight are saved as compared with similar steel bodies, which, of course, can be added to the net pay load. It may be of interest to note that when this body was designed, it was evident that, in order to make its manufacture practicable, it would be very desirable to fabricate the material by spot welding the aluminum alloy parts rather than by riveting them. In order to make this possible, it was necessary for the body builders to inaugurate new manufacturing practices and provide suitable welding equipment. After some experimenting

and testing, this new practice is working out very satisfactorily. Arc and gas welding were tried, but spot welding was found to be far superior for this work because of the better control of the welding heat.

While the use of aluminum in the body adds approximately 50 per cent to the cost of the finished product, there will be a somewhat greater recovery value when the units are finally disposed of. The use of a lighter, less expensive chassis is permitted. The aluminum alloy provides a painting surface which is free from rust chipping, similar to the result obtained with galvanized steel surfaces.

As another general type of body design, in some cases very satisfactory results have been obtained through using light commercial panel trucks carrying specially designed inside equipment, as in the installer-repairman units known as the "RI" bodies. In order to add as little as possible to the weight of the panel bodies, which in themselves are rather heavy, and thus provide the maximum carrying capacity, the interior work, which of necessity is quite extensive, is made of aluminum alloy. In so far as practicable, identical units such as the instrument carrying trays are used in the RI, SL, and LI bodies in order to increase quantity production and reduce the cost of these units.

For a single repairman who has to do a considerable amount of traveling in connection with his work, and requires only a limited quantity of tools and supplies, a "Type R" unit is used. This consists of a business coupé having compartments, shelves, drawers, etc., specially adapted for carrying the required materials and tools, and fitted into the generous rear deck of the modern coupé. As with the LI, SL, CS and RI bodies already mentioned, the type R units are equipped with facilities for carrying an extension ladder clamped in supports at the side of the body.

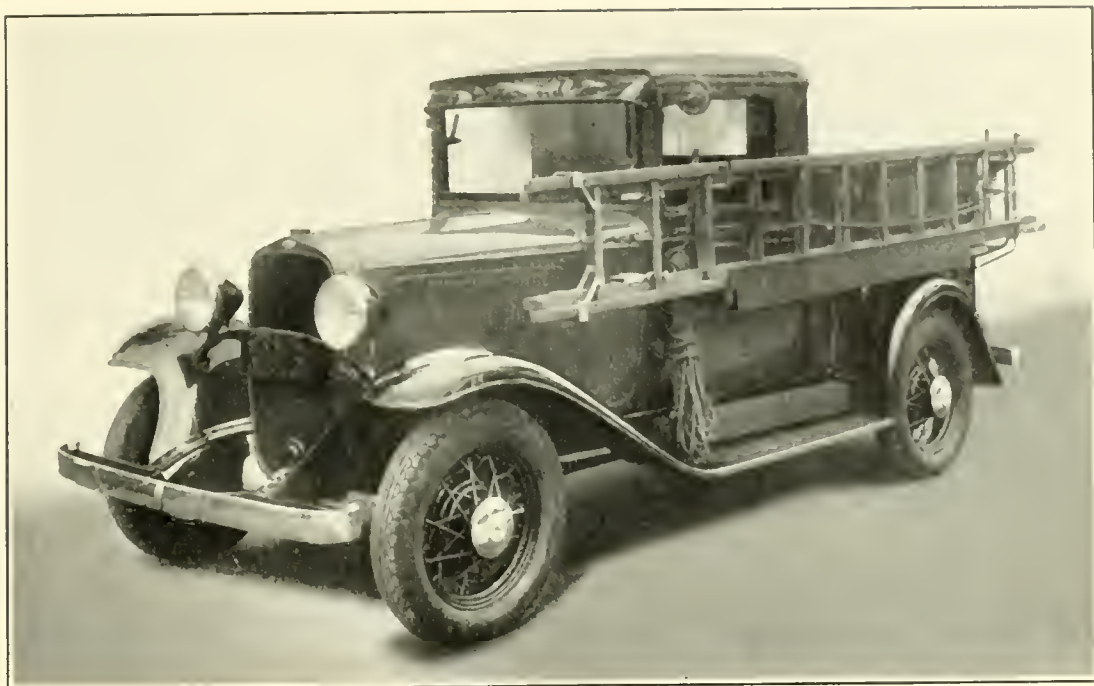
Advancing now to the heavier duty trucks, a broadly used type is represented by the new light pole line and cable con-

struction and maintenance unit of the "LCW" classification. This unit represents the latest development in its class. It is now undergoing field trials and will very soon be available for all Bell System Companies. The LCW unit is designed for the purpose of providing all of the desirable auxiliary power equipment, as well as many other facilities which are outlined below. By utilizing low priced, large production 1½-ton chassis and designing the bodies and other equipment to correspond, it has been possible to make available small gang trucks which have extreme flexibility, and are especially well adapted to the work, at a very low first cost and operating cost per unit.

The LCW bodies are built almost entirely of galvanized steel, of gauges as light as practicable for various parts of the units. In the construction, welding is used extensively. However, the body is so designed that, if it is necessary to ship it some distance from the point of manufacture, it can readily be disassembled into five parts, packed into a relatively small space and shipped, and then reassembled without difficulty.

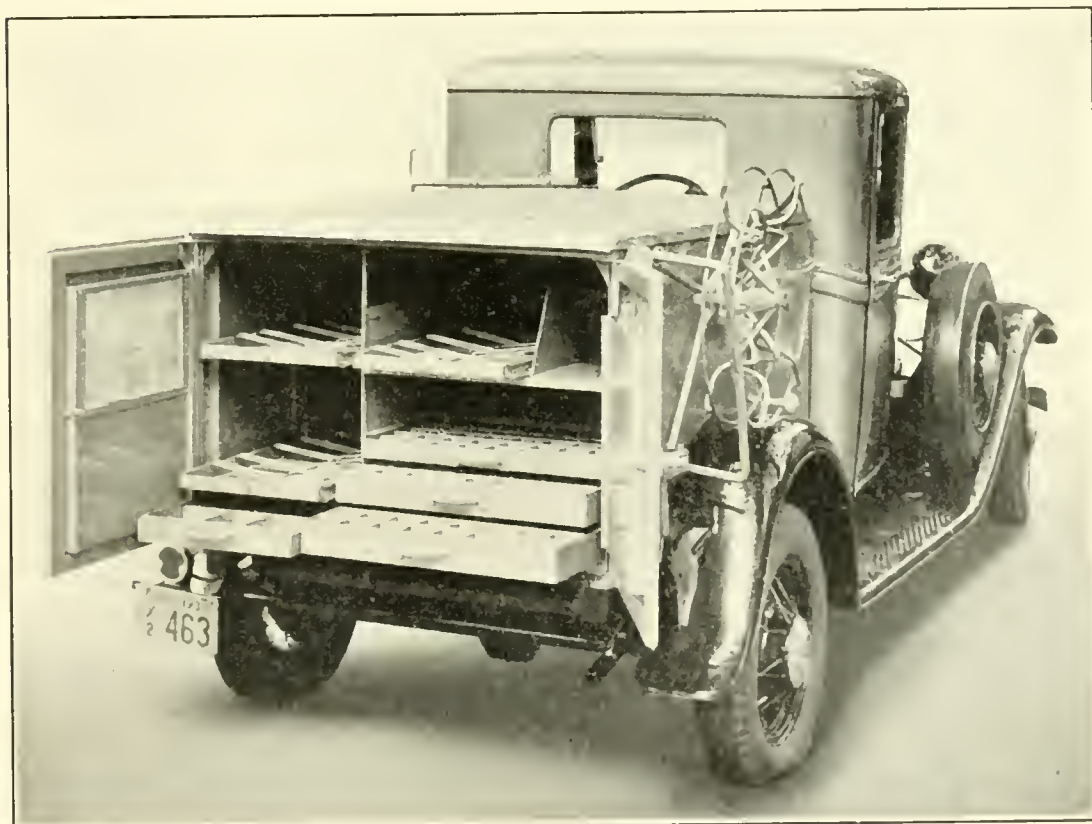
In the design of this body, special attention is given to mounting the power equipment conveniently for use and also for carrying when not in service. For instance, a hinged steel seat covers the power winch, which is located at the forward end of the body just back of the cab. When the winch is not in service, this cover, with its sponge rubber cushion, provides a comfortable seat for those of the gang who are not accommodated in the cab. The seat can easily be hinged together into a flat section and raised above and to one side, leaving free access to the winch for pole derrick work, cable pulling, etc.

When the winch seat is down, the front of the body is entirely sealed against wind and weather, as are both sides and the top, so that the men riding upon the winch seat, as well as the blocks and tackle, etc., are well protected. As a new feature of considerable convenience, the roof on the LCW bodies is of a telescoping type, so designed that it can readily be



THE LI TYPE VEHICLE.

This half-ton truck serves installers and their helpers.



REAR VIEW OF THE LI BODY.

About 1,300 of these bodies are purchased annually.



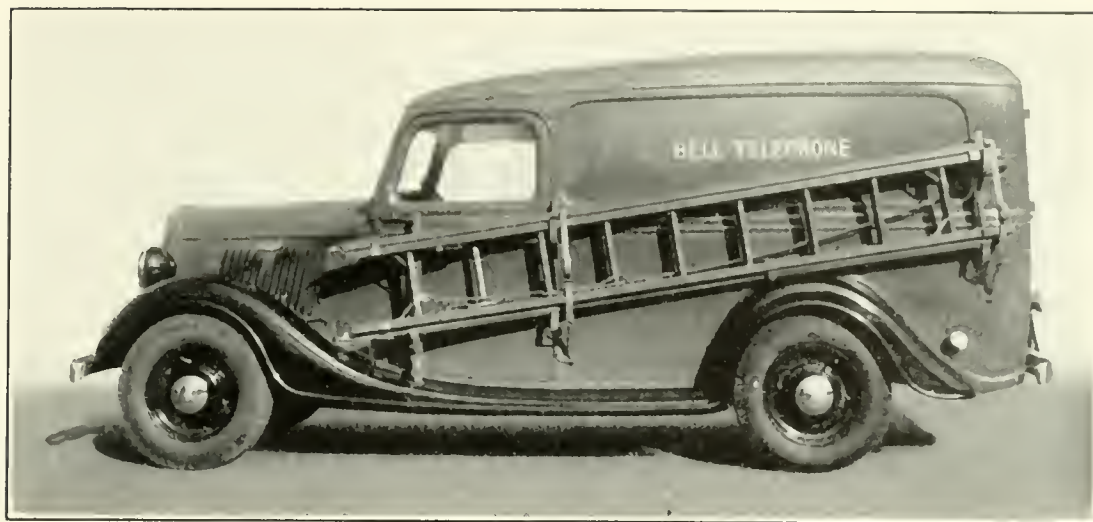
THE SL TYPE VEHICLE.

This truck is used by section linemen and installer-repairmen.



REAR VIEW OF THE SL BODY.

The roof is designed for carrying brush, or bulky materials used in repair work.



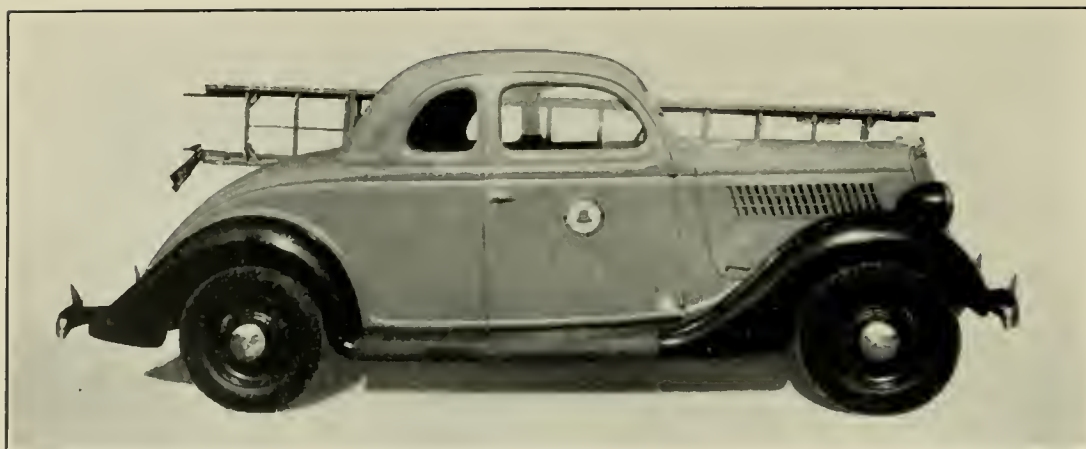
THE RI TYPE VEHICLE.

A commercial panel truck, used by installer-repairmen, with specially designed interior fittings.



REAR VIEW OF THE RI BODY.

To save weight for pay load, these interior fittings are of aluminum alloy.



THE R TYPE VEHICLE.

Used by the single repairman who has to cover considerable territory.



REAR VIEW OF THE R BODY.

Specially designed compartments, etc., fit in the coupé's rear deck.

ENGINEERING THE TELEPHONE FLEET

pulled back to cover two-thirds of the entire body or, when the roof is not desired, can be telescoped into a conveniently small space over the front of the unit. The steel plate floor of the body is of diamond grid design so that it presents a good non-skid surface.

As a first step in the design, representative lists of tools and materials to be carried by gangs of this type were studied carefully; then the side boxes, racks, compartments, shelves and partitions were so designed as to carry the proper amount of each class of equipment in a convenient, orderly manner. This consideration is very important, particularly in a truck of this type where the carrying capacity is limited. The proper arrangement and size of carrying spaces permits a quick visual inventory of the materials and tools on the truck, thus obviating an overstock and overweight of some types of equipment and an undersupply of others.

Suitable lockers are provided for carrying the men's extra clothing and their lunches. Also, as a safety precaution, it should be noted that the facilities for carrying linemen's climbers, body belts and safety straps are such as to prevent damage to the leather by the climber gaffs. The various side- and under-boxes of the body can be secured with flush locks when desired.

It is both interesting and surprising to note the great diversity and volume of construction and maintenance work that can be done with these inexpensive 1½-ton truck units. These small gangs operate in a field which in the past has been served by much heavier and more expensive equipment, ranging in size up to five tons' capacity.

The old time, heavy duty construction and maintenance units are rapidly being superseded by lighter types such as the LCW unit and the medium duty outfits represented by the "MC" trucks. The design and functioning of the MC truck is quite similar to that of the LCW. However, the body is somewhat larger, heavier, and correspondingly more expensive, in order

to fit it for use with medium sized gangs operating with 2- to 2½-ton trucks.

In connection with construction work where there is a considerable amount of pole setting to be done, the earth boring machine units are applicable. The body design for such trucks is necessarily different from that of the LCW and MC outfits. The earth boring machine truck bodies, known as "EB" units, must be very strong, particularly in the rear, to handle the severe strains transmitted to them during the earth boring operation. The tools and materials carried on the earth boring machine truck are less extensive in number and volume than on some of the other vehicles; less side-box space and less rearranging of the space are required in order to fit the particular items.

In this body, as in the LCW and MC units, the overhang back of the rear axle is limited because of the necessity of providing adequate stability. For instance, in lifting an auger filled with dirt out of a wet clay hole, the suction is so great that if there were excessive overhang back of the rear axle, the front end of the truck might be lifted off the ground. A somewhat similar condition exists in handling the pole derricks on all types of construction and maintenance bodies. These trucks are supplied with small pole derrick support members which transmit the loads to the ground under the rearmost point of the body. However, these supports cannot be used where it is necessary to move poles suspended from the derricks. Also, the springs in the trucks are strong enough to handle, unaided, all of the light and some of the medium-sized poles without the use of the pole derrick supports, so that the stability from a short body overhang back of the rear axle becomes a very desirable feature in construction and maintenance trucks.

For highway delivery of such items as reels of cable, cross-arms, conduit material, etc. open stake bodies, such as the type "M" unit are applicable. While the M bodies have not as yet

been standardized, they are mentioned as representative of a class. In these trucks, special attention must be given to the under supports and the floor construction, in order to carry safely the concentrated load which, in the case of some reels of cable, might amount to as much as three tons' pressure under one narrow reel flange. Other features of design in connection with this body have to do with suitable provision for tying down full and also empty reels, together with the proper width and length of body to accommodate the desired amount of material to be carried at any one time.

A rather highly specialized type of delivery body is used with four-wheel-drive trucks for carrying reels of cable on private right-of-way. These trucks have been used very successfully in Long Lines work, to replace slow-moving caterpillar tractor trailer outfits. They have not as yet been applied outside the Long Lines Department. Provision is made in this design for easily loading and unloading the heavy reels of cable and for holding them in position during the rough lurching ride which they experience when being hauled over private right-of-way. These four-wheel-drive outfits, equipped with powerful engines and very large pneumatic tires—dual in the rear and, when desired, also in the front—can negotiate unbelievably difficult private right-of-way conditions. It has been demonstrated on the job that they will deliver reels of cable to practically any place where this can be done with caterpillar tractors. Obviously, their use results in a considerable saving in cost as well as in time, due to their much higher speed and to the fact that they can be used to pick up a reel of cable at a railroad siding and deliver it to location, as compared with the older method of hauling the cable by truck to the edge of the right-of-way, where the reels are unloaded and then picked up by caterpillar tractor trailer outfits. A very strong steel reinforced body of comparatively small size is used in the trucks which handle this work.

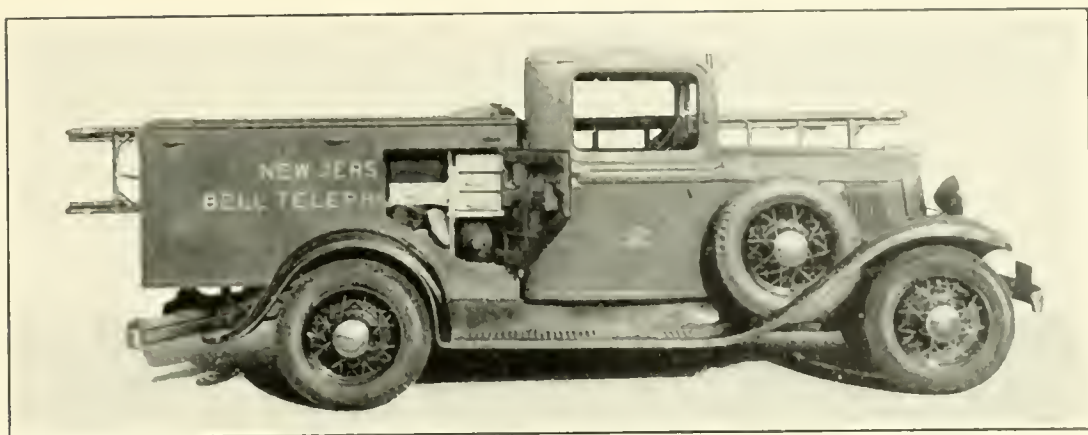
As representative of present day truck body development in

another branch of the telephone field, the experimental supply delivery panel outfit might be mentioned. This large body carries supplies from central storerooms to garages at night, where the many items required by various installation, construction, and maintenance trucks are taken from the supply delivery body and distributed directly to the trucks which will use the supplies on the following day. The body is built as low as practicable, in order to reach easily all portions of the shelving from the outside. Long doors on each side of the body, hinged at the bottom, open down to a horizontal position, where they rest upon telescoping pipe supports pulled out from underneath the body. In this horizontal position the large aluminum doors serve as platforms from which all portions of the shelving can readily be reached. The bank of shelving facing out on each side of the body is of the commercial storeroom type, except that it is made of aluminum alloy in order to reduce weight. A convenient step is provided for the use of the operator in stepping up and down from the floor to the platform. When closed, these doors form a water-tight cover for the lower portion of the shelving; the upper portion is covered by light, strong metal and fabric curtains carried in weather-proof guides.

Inside this supply delivery body, between the two panels of shelving, is an aisle which extends along the middle to the front of the body and across the front, with doors at the rear and on one side in front. Since, with this design, access to the shelving is not necessary from the inside of the body, the T shaped space inside is filled with bulky supplies which are removed as required and which do not interfere with access to the small material from the outside.

In order to permit easy maneuvering of this unit, with its long body, and also to economize in space required at the loading platform, a "camel back" (engine under the cab) type of chassis is being utilized.

As a further development in the supply delivery field, a de-



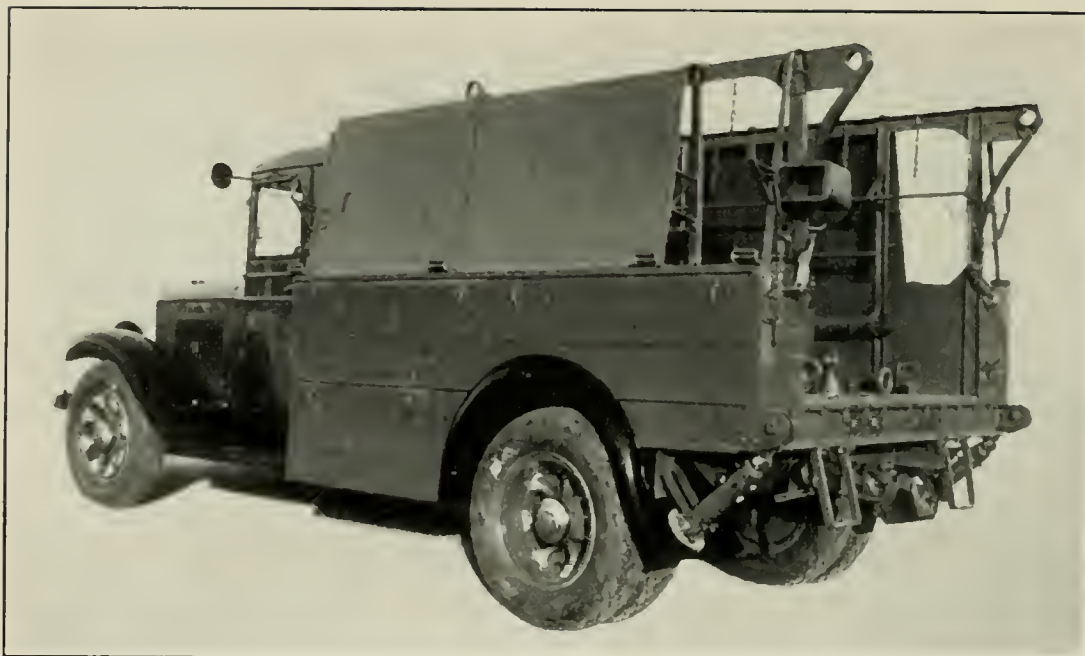
THE CS TYPE VEHICLE.

For the use of the splicer-repairman; this body is fabricated of aluminum alloy, to permit of a large body on a small chassis.



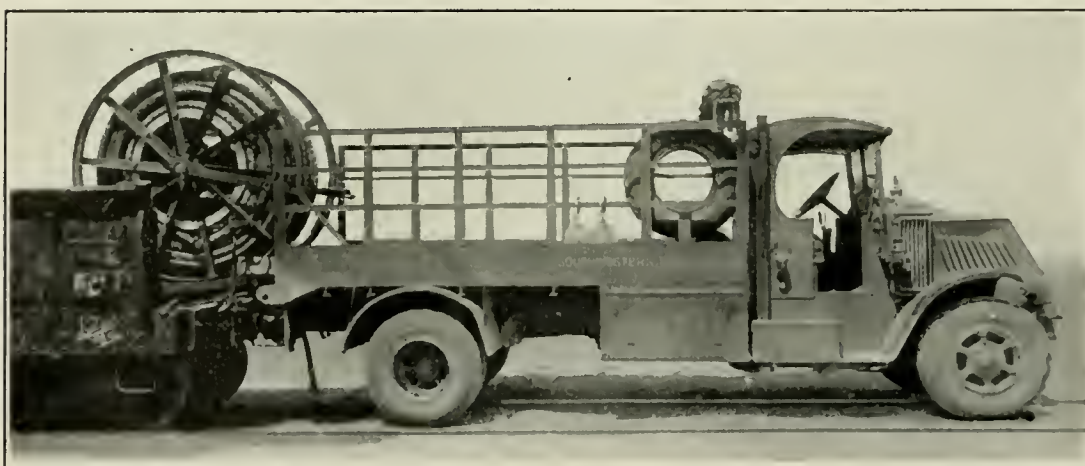
THE LCW TYPE VEHICLE.

A light truck with ample storage and auxiliary power facilities, to serve small construction and maintenance gangs.



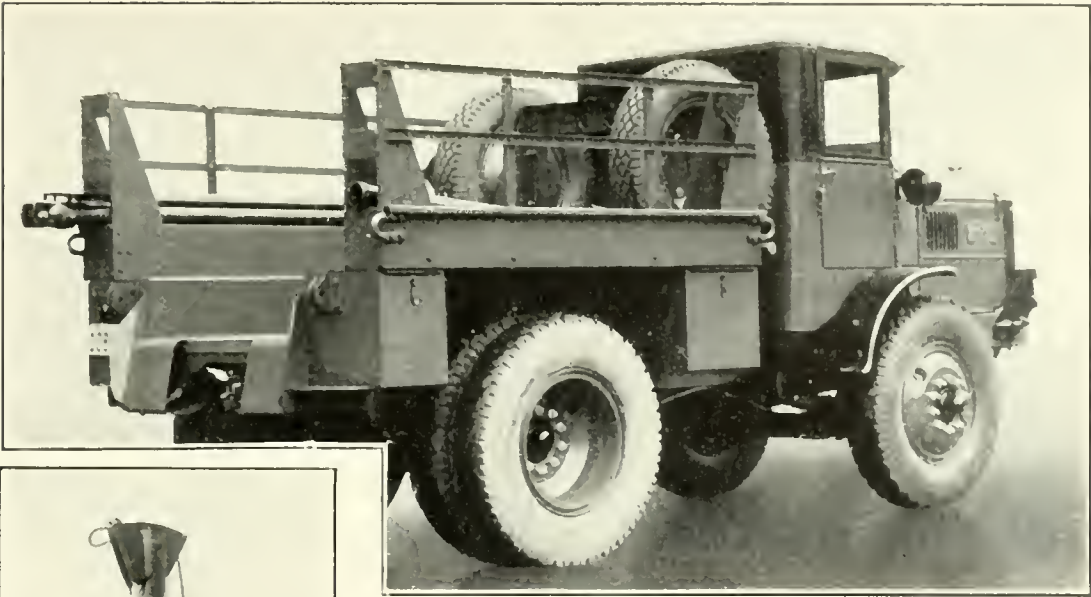
THE MC TYPE VEHICLE.

A medium duty construction and maintenance truck.



THE M TYPE VEHICLE.

A heavy duty delivery truck.

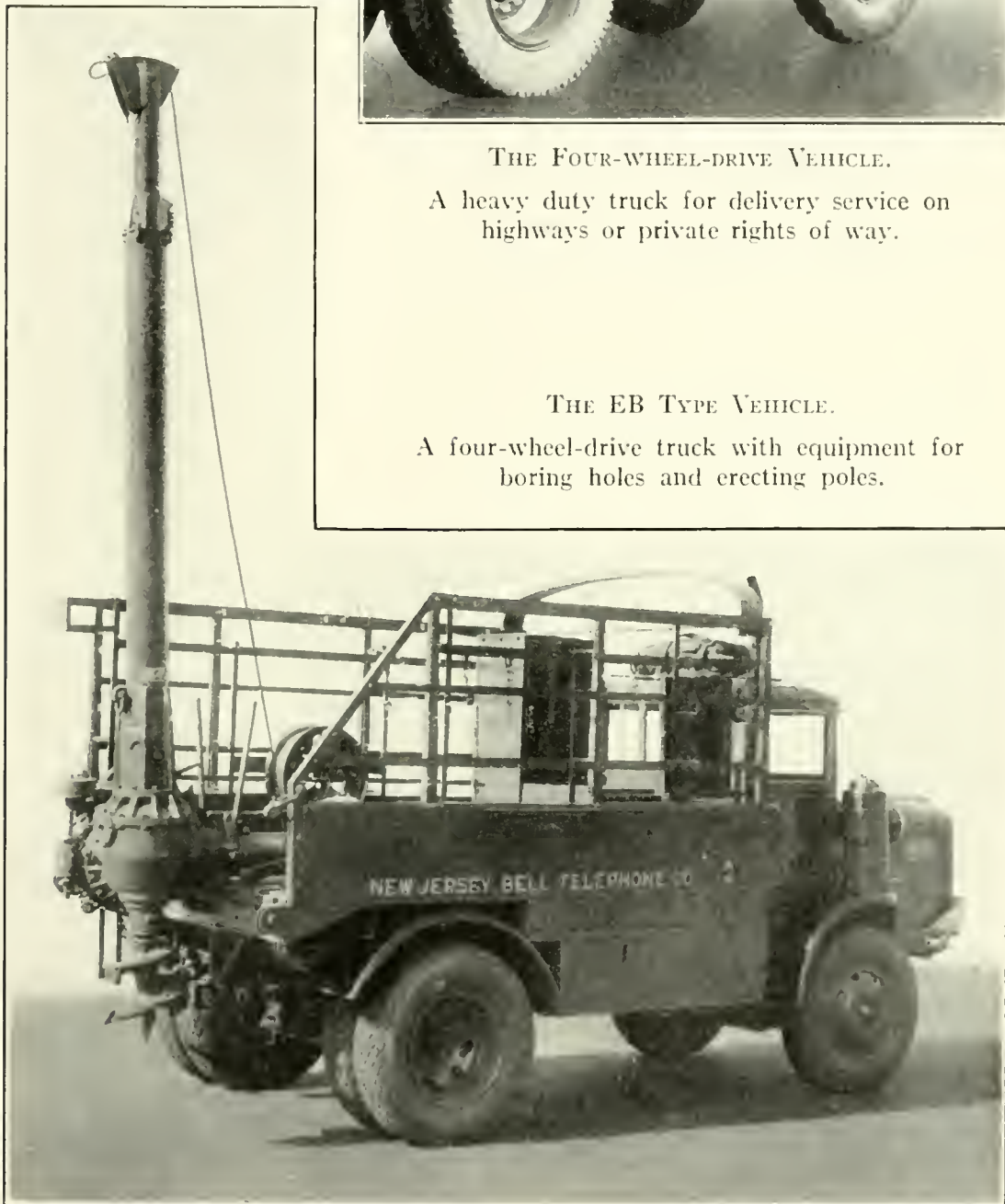


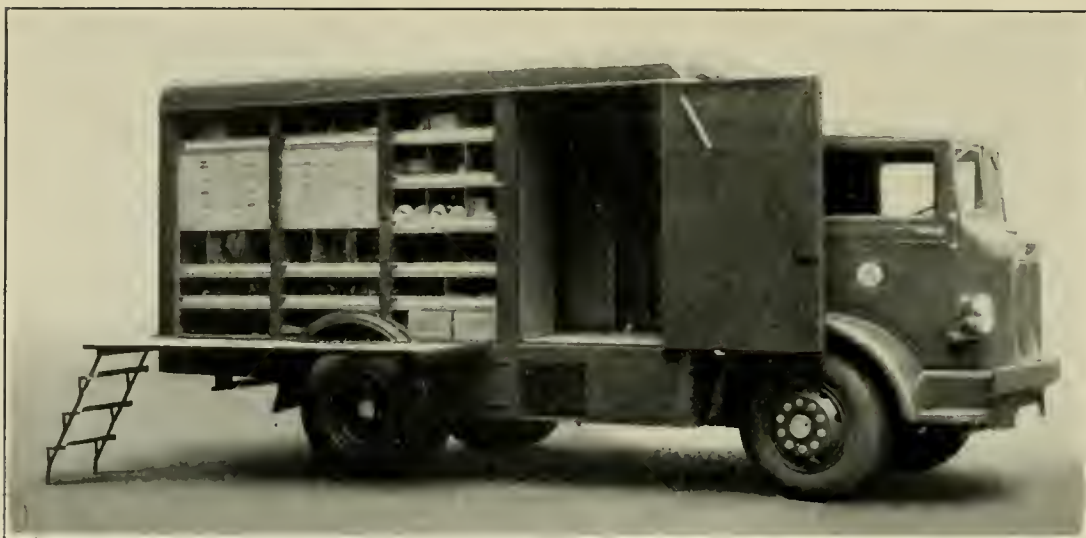
THE FOUR-WHEEL-DRIVE VEHICLE.

A heavy duty truck for delivery service on highways or private rights of way.

THE EB TYPE VEHICLE.

A four-wheel-drive truck with equipment for boring holes and erecting poles.





THE SD TYPE VEHICLE.

For carrying supplies from central store rooms to garages, where working trucks are loaded at night in preparation for the next day's work.



THE SD TYPE VEHICLE.

Showing the body closed, and the "camel back" type of front construction

sign has just been completed covering a body coded "SD," of practically the same size as the one mentioned above but having radically different features. Access to the shelves in the SD body is entirely from the inside. The space occupied by the shelving is practically the same as in the earlier body, but the shelving, in sections, is carried on four specially designed, castor mounted, hand trucks, each of which when loaded will weigh approximately 1200 pounds. These hand trucks are rolled out of the body and left in the storeroom during the daytime to be filled, while the truck is available for delivering booths or other supplies. In the evening the truck is returned to the storeroom; the loaded hand trucks, which, due to their design, can be handled by one or two men, are rolled into the positions provided for them in the truck body and clamped into place; and, as with the earlier body, the supplies are delivered to the waiting vehicles in various garages.

From the descriptions of features incorporated in these various representative truck bodies for their several types of work, it is evident that in order to handle this work economically and expeditiously, it is very desirable that each class of vehicle be studied with a view to adapting it to the type of service in which it will be used. Ordinarily in telephone work there is very little necessity for shifting a vehicle from one general class of work to another, and since a unit will probably be operated in a particular kind of service for from four to eight years, foresight in properly adapting the body to carry its greatly diversified load will pay large dividends through assisting the workmen in their day-to-day assignments over this long period of time. Another factor, which has only been mentioned and which is given very careful consideration in all designs, is that of safety both to the public and to the workmen. When tools and materials, particularly of the heavy types, are carried in an orderly manner and provision is made for properly securing them in place, an important step has been taken toward safe operation.

By careful study, the number of types of bodies in the field is kept at a minimum consistent with proper utility, in order to obtain quantity production and thus lower prices in the manufacture. Taking the average vehicle life at five or six years for the 17,000 vehicles in the Bell System fleet, and considering the fact that a very large majority of these are work cars, it is realized that the average annual turn-over in work cars is large. As a result, there arises the important opportunity for securing beneficial results from proper truck body designs.

T. C. SMITH

A Decade of Awards to the Scientists and Engineers of the Bell Telephone System

THE Hall of Fame, overlooking the majestic Hudson as it nears the ocean at New York, commemorates those famous men and women who have been deceased at least a quarter-century. Twenty-five years must elapse after death before a great personage becomes eligible for inclusion in its roster. There is a general impression that oftentimes merit, talent, and genius are not rewarded during one's life—that appreciation and recognition are often belated. Happily, this impression is in many cases incorrect. Medals, prizes, and orders awarded to men and women in many fields of endeavor—science, education, social service, religion, politics, engineering, et cetera—are frequently described in current magazines and newspapers, and, in these cases, the living person has the gratifying knowledge that his work has been acceptable to his profession and to his own age.

The engineers and scientists of the Bell Telephone System have been especially honored by contemporary organizations at home and abroad in the recognition accorded their achievements in the art and practice of electrical communication. Of the men and their work in this field of endeavor, Dr. Frank B. Jewett, President of the Bell Telephone Laboratories, in a recent address before the National Academy of Sciences, spoke as follows:

“Obviously, an achievement so intricate and vast as the whole of present-day electrical communication has been contributed to by many men in many lands. Their contributions have been of science, inventions, engineering, organization, and operation. With full credit to all others it is, I think, no derogation to say that electrical communication is essentially and

most largely an American thing, possibly our greatest and most unique contribution in the field of applied science. . . ."

That electrical communication is "possibly America's greatest and most unique contribution in the field of applied science" is attested by the number of medals, prizes, and awards that have been given to engineers and scientists of the Bell Telephone System. In the last decade, academies of science, institutions of engineering, and foundations, in America and abroad, as well as foreign governments, have recognized twenty-six outstanding contributions by living members of the technical staff. That during 1935, seven men have been awarded distinguished honors by one foreign government, two foreign scientific societies, and three American organizations, is particularly worthy of note.

The researches and accomplishments of the men of the Bell Telephone System who have thus been signally recognized with medals, prizes, and orders are briefly described in the pages which follow.

1925. THE JOHN SCOTT MEDAL

AWARDED BY THE CITY OF PHILADELPHIA TO
WILLIAM G. HOUSEKEEPER

Metals and glasses do not ordinarily stick to one another. At high temperature, when glass is in liquid form, it was found it would wet, that is, stick to copper. Later, at ordinary temperature, the two substances still adhered. In order to make high-power thermionic vacuum tubes for radio telephony and broadcasting, metal and glass must so adhere as to give an hermetic seal. Copper-glass seals usually fail because of the shrinkage of the copper away from the glass. Mr. Housekeeper discovered that this shrinkage can be prevented if either of the two substances is thin enough in comparison with the other so that it can be stretched or compressed by its heavier team-mate. Due to its great ductility, copper is usually se-

A DECADE OF AWARDS

lected as the element to yield during cooling. From the metal part of the tube, heat necessarily accompanying the operation of the tube can be dissipated by water running in contact with it. The John Scott Medal is awarded by the City of Philadelphia from the proceeds of a fund left more than one hundred years ago by John Scott of Edinburgh, Scotland.

1925. THE MORRIS LIEBMANN MEMORIAL PRIZE

AWARDED BY THE INSTITUTE OF RADIO ENGINEERS TO
JOHN R. CARSON

Mathematics was recognized in the awarding of the Morris Liebmann Memorial Prize by the Institute of Radio Engineers to Mr. John R. Carson, a distinguished physicist and engineer. Mr. Carson discovered a new and improved and more efficient system of radio and wire transmission by means of mathematical investigations. "Single sideband, suppressed carrier system of wave transmission" is the technical name given to the invention. Electric circuit theory and the theory of selective circuits are also mentioned in the citation of Mr. Carson's work.

This Institute of Radio Engineers prize was established in 1919 by Mr. E. J. Simon now an electrical manufacturer of New York, in memory of Lieutenant-Colonel Morris Liebmann, killed in action in France in 1918. Mr. Liebmann was one of the early manufacturers of wireless and associated electrical equipment of 1900-1915.

1926. THE JOHN SCOTT MEDAL

AWARDED BY THE CITY OF PHILADELPHIA TO
GUSTAF WALDEMAR ELMEN

Where dynamic electricity is, there also is magnetism. Magnetic materials play as important a rôle in communication as do copper wires and batteries and switchboards and poles.

In every telephone receiver and every telephone circuit, one or more magnets will be found. For new and striking discoveries in magnetic alloys of iron, nickel, and cobalt, and particularly the invention of permalloy, an alloy of nickel and iron, Mr. Elmen was awarded the John Scott Medal by the Board of City Trustees in Philadelphia. As found in nature, iron, nickel, and cobalt individually possess magnetic properties serviceable for the needs of man. However, by alloying, the resultant metal possesses the same properties different in degree by many-fold less or many-fold more, and thereby serves better than the native substances.

Permalloy finds most striking use in the cores of telephone transformers and "loading" coils and in certain telephone receivers, and also in the adding of magnetic properties to submarine telegraph cables whereby a cable is enabled to carry several-fold more words per minute than previous types of cable.

1926. THE PHOTOGRAPHIC MEDAL

AWARDED BY THE ROYAL PHOTOGRAPHIC SOCIETY OF
GREAT BRITAIN TO

F. F. LUCAS

To photograph what the eye cannot of itself see, oftentimes gives a clue as to the acceptability of material for use in telephone apparatus. For extraordinary ability to manipulate, control, and operate photomicrographic apparatus and for his exhibit of high power microphotographs of metallurgical specimens, Mr. Lucas was awarded the Photographic Medal of the Royal Photographic Society of Great Britain.

A DECADE OF AWARDS

1927. THE MORRIS LIEBMANN MEMORIAL PRIZE

AWARDED BY THE INSTITUTE OF RADIO ENGINEERS TO
RALPH BOWN

In 1927, commercial radio telephone service was established between America and Europe. Today, many commercial radio telephone circuits connect the United States with South America, Honolulu, the Philippine Islands, Bermuda, many other countries, and ships at sea. Ninety-three per cent of the world's telephones may be reached from the United States by radio and wire circuits.

Prior to 1927, many researches on a wide front were conducted in the field of radio transmission under the direction of Mr. Ralph Bown. In recognition of his researches in wave transmission phenomena, he was awarded the Morris Liebmann Memorial Prize. He has been an outstanding exponent of the development of methods and equipment to place radio on a quantitative and engineering basis rather than on a hit-and-miss and qualitative basis.

1927. THE JOHN SCOTT MEDAL

AWARDED BY THE CITY OF PHILADELPHIA TO
HERBERT E. IVES

A Chinese proverb states that one picture is worth a thousand words. Electrical circuits carry speech and telegraph signals and, in addition, may be used for the transmission of electrical impulses to control a source of light which eventually affects an undeveloped photographic plate. For his share in the development of a method for transmitting pictures over telephone lines and for the further development of television either over land wires or by radio, Mr. Herbert E. Ives was awarded the John Scott Medal. John Scott, a native of Scot-

land and later a resident of Philadelphia, wished to honor scientists "responsible for useful inventions for the use and benefit of mankind."

1928. THE JOHN FRITZ MEDAL

AWARDED BY THE FOUR MAJOR ENGINEERING SOCIETIES OF
THE UNITED STATES TO

J. J. CARTY

General J. J. Carty, formerly Vice President of the American Telephone and Telegraph Company, was for many years its Chief Engineer and later had charge of its development and research program. Under his leadership and inspiration, many outstanding developments in the communication art and business were conceived, planned, developed and put into practice. His imagination foresaw, his mind planned, and his skill fashioned many creative advances in radio and wire telephony. Throughout the many years of his active life, he was literally showered with degrees, honors and medals.

In 1928 the four major engineering societies of Mechanical, Electrical, Mining and Metallurgy, and Civil Engineering awarded General Carty the John Fritz Medal. The Medal was established in 1902 in honor of John Fritz of Bethlehem, Pa., a pioneer in the steel industry. The citation for this medal reads "For pioneer achievement in telephone engineering and in the development of scientific research in the telephone art."

The first medal awarded to General Carty was the Edward Longstreth Medal of the Franklin Institute in 1903. In 1916 the Franklin Medal, the highest award within the gift of the Franklin Institute, was given to him at a "Carty-Hall" meeting in Philadelphia. On this occasion a demonstration of wireless and transcontinental telephony was presented. New York had at that time been talking to San Francisco on a commercial telephone basis for about a year. The Thomas A. Edi-

A DECADE OF AWARDS

son Medal was awarded to him in 1918 for "work in the science and art of telephone engineering."

For notable work in the Signal Corps during the Great War, he was awarded the Distinguished Service Medal by the United States Government in 1919 and was made "Officier de Legion d'Honneur" by the French Government in the same year. The Japanese Government honored General Carty by naming him to the Order of the Rising Sun in 1909 and the Order of the Sacred Treasure in 1912.

1928. THE ELLIOT CRESSON MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO

GUSTAF WALDEMAR ELMEN

This medal was founded in 1848 by Elliot Cresson, a merchant and philanthropist of Philadelphia. It is awarded annually for "discovery or original research adding to the sum of human knowledge, irrespective of commercial value, and also leading to practical utilizations of discovery." This medal, as was the John Scott Medal in 1926, was given to Mr. Elmen for extended researches in the magnetic characteristics of nickel-iron alloys resulting in permalloy.

The Franklin Institute of Philadelphia, named in honor of America's first great experimenter in electricity, was founded in 1824. One of its purposes is to "present, exhibit or discuss new inventions, discoveries or important engineering projects and notable achievements in all fields of scientific progress."

1928. THE JOHN SCOTT MEDAL

AWARDED BY THE CITY OF PHILADELPHIA TO

H. D. ARNOLD

In the address of Dr. Jewett before The National Academy of Sciences, previously referred to, he said: "Before 1915, nature could say to man, 'there are limitations of distance be-

yond which you cannot go in intimate and personal conversation with your fellow-men; you must work out your destiny within this limitation.' After 1915, man could say to nature: 'there are no limits of distance or physical circumstance which you can any longer impose upon me as regards my need or desire to speak face-to-face with men anywhere; from now on I propose to work out my destiny free from this shackle of the past.'"

One of the instrumentalities, a key, as it were, which unlocked the confining doors, was the vacuum tube, the result of the brilliant research in electronics of a number of workers, one of whom was Mr. H. D. Arnold. In 1912, the "audion" of Dr. Lee de Forest was a very crude device, incapable of being used as an amplifier of voice currents in long distance telephony. Mr. Arnold recognized the possibilities inherent in this device and undertook a development which, starting on the basis of the "audion," resulted in the production of the modern three-electrode high-vacuum thermionic tube. It is adaptable to a wide range of purposes and was specifically developed by him for commercial use in long distance wire and radio communication.

Mr. Arnold's particular contributions were the appreciation of the necessity of a high vacuum and a development and application of methods for obtaining such a vacuum. He developed designs for tubes and methods for their manufacture so that they could be reproduced with accuracy and so that dependable and interchangeable tubes could be made to meet telephonic requirements of reliability and ease of maintenance.

While a telephone conversation between Los Angeles and New York is taking place, over 200 thermionic vacuum tubes are functioning in the telephone repeater and transmission apparatus. The greatest distance with which man has to deal is "around the world," since talking to "the man in Mars" would involve celestial rather than mundane distances. In the summer of 1935, a round-the-world telephone call, from New York

to New York, was made, in which 980 vacuum tubes played their versatile rôles. At the present time there are about 350,000 vacuum tubes in the Bell Telephone wire and radio systems.

For his notable researches Mr. Arnold was awarded the John Scott Medal "for the development of the three-electrode high-vacuum tube."

1928. THE COMSTOCK PRIZE

AWARDED BY THE NATIONAL ACADEMY OF SCIENCES TO

CLINTON J. DAVISSON

Electrons have been the subject of study and research by many distinguished scientists: Sir Joseph Thomson of Great Britain, Lorentz of Holland, Millikan of the United States, and many others. In the field of vacuum tubes for radio and wire telephony, the word "electron" has become a word in the vocabulary of day-to-day conversation even in lay circles. It was generally considered that an electron was a discrete particle of negative electricity. However, through experimental work Mr. Davisson demonstrated that under certain conditions electrons behave as trains of waves might be expected to behave. Electrons were diffracted when a stream of them was shot into a suitable crystal, nickel for example. Diffraction is a well known and simple phenomenon, always accepted as proving that light was a wave phenomenon. The striated or narrow-lined structure of birds' feathers, producing by reflected light beautiful iridescent color effects, is an example of the phenomenon of diffraction. According to Laue and Bragg, the atoms in a crystal are arranged in regular patterns of various types. Hence, if electrons shot at a crystal emerged in a few sharply defined beams, the phenomenon is similar to the reflection of light from the striated structure of a feather. If electrons were diffracted, they were behaving as trains of waves.

Every five years the National Academy of Sciences awards

the Comstock Prize "for the most important discovery of or investigation in electricity or magnetism or radiant energy." To Mr. Davisson it was granted "for experimental work demonstrating that under certain conditions electrons behave as trains of waves might be expected to behave."

General C. B. Comstock was a distinguished engineer and soldier during the years of the Civil War, retiring from the U. S. Army in 1895. He was a pioneer in geodetic survey work.

1929. THE EDISON MEDAL

AWARDED BY THE AMERICAN INSTITUTE OF ELECTRICAL
ENGINEERS TO

FRANK B. JEWETT

Annually a committee of twenty-four members of the American Institute of Electrical Engineers awards the Thomas A. Edison Medal "for meritorious achievement in electrical science, electrical engineering, or the electrical arts." In his response at the presentation of this medal, Dr. Jewett said: "The history of the development of telephony is one of coöperative effort with scarcely a parallel in the domain of applied science. . . . No-where else is the industrial research organization more potent, more firmly incorporated into the business structure, or more relied upon as a weapon of attack on problems yet unsolved. . . .

"As one who has been a part of the unfolding pageant of telephony for the past 25 years, I am not unmindful of the influence others have had in whatever I have accomplished. In accepting this medal, the highest and most cherished honor which American Electrical Engineers have it in their power to bestow, I do so, therefore, with a deep feeling that in large measure I am accepting your appreciation for the work of all the numerous men who have been my intimate associates. On

their behalf as well as my own, I thank you for your signal recognition of our endeavors."

In 1919 Dr. Jewett was awarded the Distinguished Service Medal by the United States Government, "for exceptionally meritorious and conspicuous service in connection with the development of the radio telephone and the development and production of other technical apparatus for the Army."

1929. THE PHOTOGRAPHIC MEDAL

AWARDED BY THE ROYAL PHOTOGRAPHIC SOCIETY OF GREAT
BRITAIN TO

F. F. LUCAS

Recognition of the outstanding work of Mr. Lucas in the application of photomicrography to metallurgy was made by the awarding of the medal of the Royal Photographic Society of Great Britain in 1926. For his application of photomicrographs of living tumor cells taken by means of ultra-violet light, he was again awarded the medal of the same society in 1929. These photomicrographs show for the first time his new method of optical sectioning. Just as the microscope reveals horizons not visible to the naked eye, so, most interestingly, ultra-violet light, by which the human eye cannot see, enables the microscopic eye to see still wider horizons. The technician says that, since the wave-length of ultra-violet light is less than that of visible light, the resolving power of the microscope is greater than that of the human eye. In the end, therefore, photographic plates (artificial chemical retinas) show the minutiae of structure in pictures taken with light to which human retinas do not respond with a sense of vision.

BELL TELEPHONE QUARTERLY

1930. THE DUDLEY MEDAL

AWARDED BY THE AMERICAN SOCIETY FOR TESTING
MATERIALS TO

J. R. TOWNSEND AND W. A. STRAW

Seemingly more prosaic problems than those presented in the work of the medal winners named above are those problems dealing with strength, wearing properties, resistance to rust, hardness. However, in constructing and erecting and supporting telephone apparatus in central offices and out of doors, problems connected with the above properties become very real and have wide economic value. For their work embodied in the paper "Physical Properties and Methods of Testing for Some Sheet Non-Ferrous Metals," Mr. Townsend of the Bell Telephone Laboratories and Mr. Straw of the Western Electric Company were awarded the Dudley Medal.

Dr. C. B. Dudley, formerly Chief Chemist for the Pennsylvania Railroad was one of the organizers and the first President (1902-1909) of the American Society for the Testing of Materials. The medal was established in his honor in 1925.

1930. THE THIRD ORDER OF THE SACRED
TREASURE

AWARDED BY THE EMPEROR OF JAPAN TO

FRANK B. JEWETT

The Order of the Sacred Treasure is conferred by His Majesty the Emperor of Japan. At a meeting in New York, the diploma and decoration of the Order were presented to Dr. Jewett on behalf of the Emperor by the Consul-General of Japan, "in appreciation of the most valuable services in the development of the telephone and telegraph industry in Japan." Dr. Jewett also holds the Fourth Order of the Rising Sun, likewise conferred by the Emperor of Japan in 1923.

A DECADE OF AWARDS

1931. THE ELLIOT CRESSON MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO
CLINTON J. DAVISSON

Further recognition of the distinguished researches of Mr. C. J. Davisson was made by the Franklin Institute in awarding the Elliot Cresson Medal "in consideration of pioneer work in the scattering and diffraction of electrons by crystals and of its direct bearing on our theory of the constitution of matter."

1931. THE ELLIOT CRESSON MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO
L. H. GERMER

Associated with Mr. Davisson in his researches has been Mr. L. H. Germer, and to him also was awarded an Elliot Cresson Medal. Messrs. Davisson and Germer were able to calculate from their experiments the "wave-length" of electrons, and the values obtained check closely with those announced by de Broglie in France.

1931. THE JOHN PRICE WETHERILL MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO
E. C. WENTE

The conversion of the sound waves of speech into electrical impulses was the notable discovery of Alexander Graham Bell. In the transmitters of the more than 33,000,000 telephones in the world, this conversion is daily accomplished through the medium of carbon granules. It is recognized today that there are several methods by which this conversion can take place. In other words, there are several kinds of distinctly different electrical ears which can hear sounds. One of these electrical ears or microphones is known as the electrostatic transmitter,

consisting essentially of two thin metallic membranes placed very close to each other. When sound waves strike one of the plates, the electrostatic condition of the plates is changed and a tiny electric current results. This transmitter had received relatively little attention and development work because it was so very insensitive to sound waves and needed an amplifier immediately associated with it to enlarge the very tiny electric currents to which it gave rise. The invention of the vacuum tube amplifier overcame this insensitivity and made it possible for Mr. E. C. Wentz to proceed with the development of a practical electrostatic transmitter. It was found that, to compensate for its great insensitivity, it would hear with great fidelity and could be used at times where the esthetic values of music and the dramatic values of speech were more essential than in everyday telephone conversation. This electrical ear became a "Mike" in broadcasting studios. For his work on and development of the electrostatic transmitter, the John Price Wetherill Medal was conferred on Mr. Wentz.

John Price Wetherill was another of those early Philadelphians interested in science and its application to industry. He called himself a manufacturing chemist and was of the 1840 era.

1932 THE MORRIS LIEBMANN MEMORIAL PRIZE

AWARDED BY THE INSTITUTE OF RADIO ENGINEERS TO
EDMOND BRUCE

The great advantage of telephonic communication by wire is that the conversation between the persons concerned is direct and private. Each day in the United States over 75,000,000 of these individual, personal, two-way telephone calls are made. On the other hand, radio waves lend themselves admirably to the situation where it is desirable to have many persons listen to one voice, as is the case in radio broadcasting. If radio waves are left to their own simplest devices, they will

spread and radiate in all directions. However, in certain circumstances of radio telephony, it is highly desirable that the radio waves go in a particular direction with a much greater degree of efficiency than in some other direction. This is true of light waves where reflectors are used to send light waves in a beam to some particular point. In radio waves the expression "beam systems" has therefore come into vogue. The Institute of Radio Engineers recognized the very important work of Mr. Bruce in this problem of developing antennas which would send their radio waves better in one direction than in another. "For his theoretical investigations and field developments in the domain of directive antennas" he was awarded the Morris Liebmann Memorial Prize.

1932. THE EDISON MEDAL

AWARDED BY THE AMERICAN INSTITUTE OF ELECTRICAL
ENGINEERS TO

BANCROFT GHERARDI

The Communication facilities of the Bell System have grown with the nation. To engineer them, construct them, maintain and operate them has called for a rare combination of engineering knowledge and of executive force and wisdom. Forty years of engineering accomplishments is the span of Bancroft Gherardi's notable contribution to American telephony. He had as his responsibilities such important undertakings as the first long underground cable from Boston to Washington; the vast transcontinental telephone project; the introduction of dial operation in large cities; and many other outstanding advancements in communication. As Chief Engineer and Vice President of the American Telephone and Telegraph Company, he has supervised a far flung activity that only those can appreciate who remember the vastness of America and the complexity of her communication needs. His part has been a distinguished one in the creation of communication services,

and in the development of the men and women on whose loyalties and abilities must rest the progress of any great undertaking.

In 1928, when Mr. Gherardi was President of the American Institute of Electrical Engineers, he dubbed General J. J. Carty the dean of telephone engineers. That appropriate soubriquet may now fittingly be applied to Mr. Gherardi. "For his contributions to the art of telephone engineering and the development of electrical communication," is the citation accompanying the award to him by the American Institute of Electrical Engineers of the Thomas A. Edison Medal.

In 1923 the Emperor of Japan conferred upon him the Emblem of the Fourth Order of the Rising Sun.

1935. THE JOHN PRICE WETHERILL MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO

F. F. LUCAS

Further recognition of the outstanding contributions of Mr. Lucas in the field of photomicrography was made in the award to him of the John Price Wetherill Medal by the Franklin Institute of Philadelphia. The citation reads: "This medal is awarded in consideration of his development of a technique of microscopy and photomicrography by virtue of which objectives of the highest numerical aperture yet developed and visible light and ultra-violet light have been brought to their full theoretical resolving power, and by the use of which photomicrographs of metallurgical and biological specimens superior to any heretofore made are now being produced under his direction."

The capability of the human eye, the microscopic eye, or the telescopic eye to see separate lines or dots which are close together as separate lines or dots, relates to the resolving power. A picket fence at a quarter-mile is just a white wall, but at a hundred feet is a fence, with discretely seen pickets. That

ultra-violet light, shorter in wave-length than visible light, gives greater resolving power and thereby makes possible the revelation of greater detail in photomicrographs, was taken advantage of by Mr. Lucas in his expert technique.

1935. THE FARADAY MEDAL

AWARDED BY THE INSTITUTION OF ELECTRICAL ENGINEERS
(GREAT BRITAIN) TO

FRANK B. JEWETT

Michael Faraday of Great Britain is sometimes called the greatest experimenter of electrical science in the history of the world. In 1931 the centenary of one of his greatest discoveries was celebrated. The principle of magnetic induction is the basis of the keystones of practically all branches of electrical engineering. In 1931, Dr. Jewett, in America, spoke by transatlantic telephone to a distinguished audience gathered in London to celebrate the Faraday discovery. On that occasion Dr. Jewett said: "In a way, there is something peculiarly fitting in this tribute which I bring you and in the manner of its delivery. Involved in it is probably more of the fruit of Faraday's works than can be encompassed in any other single happening in our modern world. For me to sit here in Boston, where Alexander Graham Bell made his great invention, based on Faraday's discovery, and address you in London, requires the application of something of all that men have learned in a hundred years in the fields to which Faraday opened the gates."

To commemorate the life and the work of Faraday, the Institution of Electrical Engineers of Great Britain established the Faraday Medal and it is awarded "either for notable scientific or industrial achievement in electrical engineering or conspicuous services rendered to the advancement of electrical science, without restriction as regards nationality, country of residence, or membership in the Institution."

The 1935 Faraday Medal was awarded to Dr. Jewett, Vice

President of the American Telephone and Telegraph Company, and President of the Bell Telephone Laboratories. In his acceptance of the Medal, Dr. Jewett reiterated the generous point of view that he had stated in accepting the Edison Medal of the American Institute of Electrical Engineers in 1929: "I therefore feel that my chief rôle during the past twenty years has been that of creating an organization designed to make industrial research profitable by turning to practical ends under controlled conditions a portion of the vast stream of new knowledge which is coming out of the world's fundamental research laboratories. . . . The achievements of the research laboratories of the Bell Telephone System are primarily the work of my associates, and in them there is relatively little personal credit due to me. In offering this brief expression of gratitude to the Institution for conferring the Faraday Medal upon me, I therefore take great pleasure in joining it with a tribute to my many associates, who have been loyal friends and coadjutors all these years."

1935. THE EDWARD LONGSTRETH MEDAL

AWARDED BY THE FRANKLIN INSTITUTE TO

EDMOND BRUCE

Mr. Bruce, to whom was awarded the Morris Liebmann Memorial Prize of the Institute of Radio Engineers in 1932, was awarded the Edward Longstreth Medal "in consideration of his design and development of antennas for short-wave communication, combining superior efficiency, higher directivity, simple construction, and effectiveness over a broad range of frequencies." These antennas have greatly improved trans-oceanic transmission and reception.

Edward Longstreth was a pioneer Philadelphia manufacturer interested particularly in steam locomotives. In 1890, a medal was established in his honor, to be administered by the Franklin Institute. Steam locomotives and short radio

A DECADE OF AWARDS

waves are quite antipodal in their heritage and utility. However, science knows no castes.

1935. THE MORRIS LIEBMANN MEMORIAL PRIZE

AWARDED BY THE INSTITUTE OF RADIO ENGINEERS TO
F. B. LLEWELLYN

As radio developments have progressed through the years, there has been increased understanding and utilization of short waves: waves one foot, three feet, ten feet long. Corresponding to these waves, the oscillations of electric current are designated as ultra-high frequencies, namely, 900,000,000; 300,000,000; 30,000,000 vibrations per second. The use of thermionic vacuum tubes in this field of ultra-high frequencies brought new problems and likewise new and smaller vacuum tubes, some of them being the size of an acorn. The Morris Liebmann Memorial Prize, won by three other Bell System engineers, was awarded to Mr. F. B. Llewellyn "for his analysis and descriptions of the effects and the reactions which occur within vacuum tubes at ultra-high frequencies."

1935. THE ORDER OF THE RISING SUN

AWARDED BY THE GOVERNMENT OF JAPAN TO
G. W. GILMAN

Radio waves ranging from 50,000 vibrations per second to 20,000,000 vibrations per second are used to span great bodies of water and link together the land telephone systems on the seven continents of the world. One of these channels of radio telephone service connects the United States and Japan. Mr. G. W. Gilman was sent to Japan in preparation for the building and putting into service of this radio telephone circuit. In recognition of his coöperative efforts in these preparations, Mr.

Gilman was presented with the Order of the Rising Sun by the Minister of Communications in Japan.

1935. THE PROGRESS MEDAL

AWARDED BY THE SOCIETY OF MOTION PICTURE ENGINEERS TO
E. C. WENTE

Electricity is a most versatile and amenable agent. In its own right it performs many functions, and, furthermore, it may be controlled by light and sound and in turn can control light and sound. The triumvirate—light, sound, and electricity—achieve a high place in the field of talking motion pictures. In recognition of his fundamental contributions and outstanding inventions in light, sound, and electricity as they apply to motion picture technology, Mr. Wente was awarded the Progress Medal. These inventions include microphones, those electrical ears which turn sound into electric current; light valves, used by the large producers of sound pictures, which are controlled by electric current and which in turn control sources of light to record the sound photographically on the film; and loud speakers, those electrical mouths which speak in accompaniment to the action on the screen. Microphones, light valves, and loud speakers—direct and indirect products of telephone technique—have been the field of research of Mr. Wente.

The Progress Medal recently established, is to be awarded from time to time as the Society decides upon outstanding contributions. Mr. Wente is the first recipient.

1935. THE DAVID HUGHES MEDAL

AWARDED BY THE ROYAL SOCIETY (LONDON) TO
CLINTON J. DAVISSON

The work of Mr. Davisson on electron diffraction has been recognized as an outstanding contribution in the field of atomic

physics. Recognition of this fact resulted in Mr. Davisson's being awarded two medals in America. Further recognition was given by the Royal Society of London in awarding him the David Hughes Medal. It is interesting to note that this same medal, established in 1900, was awarded to Alexander Graham Bell in 1913. Much of the outstanding work in atomic physics has been done in the Cambridge University Cavendish Laboratory, England. That the Hughes Medal was awarded to Mr. Davisson for his work in this field is particularly complimentary to American science.

The name of David Edward Hughes will ever be associated with printing telegraph instruments. Although born in England, 1831, his early years were spent in America. Returning to his native land, Hughes made important contributions to carbon microphones and discovered the action of the so-called "coherer" used in the early days of wireless telegraphy.

Most of the scientists and engineers whose honors have been recounted above hold the degree of Doctor of Philosophy. All but two are graduates and post-graduates of colleges and technical schools in the United States. The honorary degree of Doctor of Science has been awarded to these two who came to the research department after a number of years of practical work in the telephone operating field rather than academic halls. Only two of the entire galaxy are deceased.

Recognition of accomplishment, such as that discussed in the preceding pages, has of course always been a concomitant of the continuing development of the telephone art. Alexander Graham Bell during his lifetime received upwards of 30 medals and decorations, as well as a number of honorary degrees. The James Watt Medal in 1877, the Royal Albert Medal in 1878, the Volta Prize in 1880, the Decoration as Officier de Legion d'Honneur in 1881, the John Fritz Medal in 1907, the Elliot Cresson Medal in 1912, the David Hughes Medal of the Royal

Society of London in 1913, the Edison Medal in 1914, and the Medal of Honor for Distinguished Public Service by the Civic Forum of New York in 1917, were among his more notable honors.

That the individual talents and achievements of men should be recognized, as indicated in the preceding pages, reflects the desire of men to honor personally their fellow-men. In contrast, it is particularly noteworthy when an industry, an organization, a company, is awarded a medal. The officers of the Franklin Institute of Philadelphia in 1916 awarded the Elliot Cresson Medal to the American Telephone and Telegraph Company. Mr. Theodore N. Vail, then President of the Company, accepted the award, on which the citation reads: "To The American Telephone and Telegraph Company, in recognition of its constructive and far-seeing policy in the development of the art of telephony; in the promotion of telephone engineering; in the establishment of its telephone system in every part of the United States, and for placing all of the States of the Union in speaking communication."

James M. Barrie wrote a beguiling tale of the World War, called "Seven Days' Leave," which was dramatized and made into a motion picture play with the title "A Lady Shows Her Medals." If those of the Bell System should ever be exhibited, there would indeed be an imposing collection. Such a display of awards will doubtless never be attempted. Therefore this account can only suggest that the quality and scope of America's telephone service constitute impressive evidence of the practical significance and utility of the scientific and engineering achievements thus recognized.

J. O. PERRINE

Notes on Recent Occurrences

DR. G. A. CAMPBELL, LEADING MATHEMATICAL SCIENTIST, RETIRES AFTER 38 YEARS

ON the first of December, 1935, after thirty-eight years of active and unusually productive service as a mathematical physicist and inventor, Dr. George A. Campbell retired from active membership on the staff of the Bell Telephone Laboratories.

In 1897, thirty-eight years ago, the art of telephone transmission was in its infancy. Circuits of even a few hundred miles' length were rare, and the longest distance over which communication had been held was that separating New York and Chicago. It was at this time that Campbell, as a young man, after graduating from Massachusetts Institute of Technology and spending four years in graduate study at Harvard, Gottingen, Vienna and Paris, joined the staff of the American Telephone and Telegraph Company to engage in research.

Some years before, Heaviside had suggested that inductance, if properly applied in a long telephone circuit, should diminish rather than increase the attenuation. Campbell followed this suggestion and developed a complete theory of loading. But in his case there occurred one of those coincidences—fortunately rare in the history of science—of two investigators arriving at substantially the same result at the same time. Independently, Professor M. I. Pupin had also attacked the problem. They both applied for patents, with the result that an interference was declared, and Pupin was able to establish a slightly earlier date of conception. The loading coil interference was decided in Pupin's favor and the famous patents issued to him. The fact should be recorded, however, that Campbell's analysis of the problem—actually more detailed

than Pupin's—led him to formulate rules for the design of loading coils and their spacing which were, from the very beginning, the only ones employed in this country.

As the effectiveness of telephone instruments increased and the lengths of circuits grew, noise and crosstalk became an outstanding obstacle to telephone advance. It had been shown that this crosstalk was a complex effect resulting partly from electromagnetic and partly from electrostatic induction. In unpublished memoranda written between 1903 and 1907, Campbell pointed out that crosstalk between two circuits depends, to a considerable extent, and particularly in the case of loaded circuits, on a function of the various direct capacities between the wires of two circuits. He termed this function the "direct capacity unbalance." This work led to the invention of the well-known capacity unbalance test set, hundreds of which have been used in countless measurements in the manufacture and installation of toll cables. It was also at this time that he designed his well-known "shielded" balance, which in one form is a bridge for measuring direct capacities.

As control was gradually extended over the characteristics of telephone circuits, both from the standpoint of their transmission effectiveness and their freedom from crosstalk and noise, the art reached the point at which development emphasis shifted to the telephone repeater. Here, an entirely new line problem arose,—namely, that of avoiding singing when repeaters are adapted to two-way amplification. Up to 1912, the only type of repeater circuit used was the so-called 21-type, in which a single repeater element amplifies messages which reach it from both directions and which requires that the two associated sections of line have very similar characteristics. A well-known limitation of the 21-type repeater is its tendency to "sing" when line unbalance or amplification exceed certain rather low limits.

On the other hand, the 22-type repeater has two amplifying elements and two artificial lines, one to balance each associated

section of actual line. While the basic idea of the 22-type was old, it remained for Campbell, in a memorandum dated March 7, 1912, to reveal its properties of inherent stability. Also his words, "the use of a compensating device such as an artificial line, to reduce the amplification at the resonant frequencies to the level of the amplification at other telephonic frequencies" suggest broadly the idea of equalizing for amplitude-frequency distortion which is brought in by the selective characteristics of the line circuits or other apparatus in a long system. Furthermore, "if it became necessary merely to eliminate certain frequencies lying outside of the range required for telephony, the use of an artificial selecting circuit" is definite anticipation of the use, subsequently common in all repeaters, of low-pass filters to cut off frequencies outside of the band transmitted and thus minimize line balance difficulties.

Campbell was also the originator of the "four wire" circuit. In the same memorandum of 1912 which discussed the 22-type repeater, he suggested it as the logical extension of the one-way paths in the 22-type repeater, each path containing as many one-way amplifiers and line sections as desired.

At present, particularly in toll transmission, we find a growing use of high frequencies, the transmission of broader frequency bands and the use of the so-called "carrier" method. The electrical wave-filter in its many forms is one of the most important elements in all such systems. Indeed, the filter has, within the last few years, become almost as ubiquitous as the vacuum tube. The fundamental conception of the electric wave-filter arose out of Campbell's analysis of loaded lines and a patent was issued to him in 1917.

Effective station sets are fundamental to all good transmission. In a memorandum dated October 8, 1906, Campbell disclosed the single-transformer anti-sidetone station circuit which is achieving almost world-wide acceptance. Later, he carried out a comprehensive survey, giving assurance that all types of

circuits were considered and that those which best fitted the available transmitters and receivers were selected.

This brief note is intended only to enumerate without elaboration the more outstanding of Dr. Campbell's contributions to the art of electrical communication as they fit into the history of that art. Their diversity is such as to establish the unusual versatility of Campbell's genius. His is a career unusually productive of discoveries, inventions and patents. Dr. Campbell's achievements in the field of telephone transmission entitle him beyond question to rank first among his generation of theoretical workers in electrical communication. Yet, in common with many truly great minds, it has been his nature to avoid publicity, so that outside the circle of his immediate associates and a few of the more mathematically gifted students of his chosen branch of electrical science, his fame is far from being commensurate with his achievements.

(Condensed from a statement by Dr. F. B. Jewett in the Bell System Technical Journal for October.)

HOLIDAY OVERSEAS CALLS SET NEW RECORD

OVERSEAS telephone calls handled through the Bell System's radio telephone stations on December 24 and Christmas Day and on December 31 and New Year's Day totaled 730 messages. This compares with 566 messages during the same four days a year ago.

More than 600 of the calls were handled through the overseas switchboards in New York: 293 on Christmas and 116 on the day before, 89 on New Year's Day and 103 the previous day. All these totals exceeded previous records established in 1934-35. The greater part of this traffic at New York was with Europe, 246 of the calls on Christmas Day involving European points.

Scores of distant lands figured in these holiday calls: Europe, Africa, India, Egypt, Australia and the Far East, Central and

NOTES ON RECENT OCCURRENCES

South America; and also several ships on the high seas. Since day begins on the other side of the world from 13 to 15 hours before it does in this country, the calls from the Phillippines, Japan, and Australia arrived on December 24 and December 31.

Holiday calls of unusual interest handled over Bell System circuits included two between the Hawaiian Islands and Europe, one with London and one with Switzerland; two between Pennsylvania and Australia; one between Iowa and South Africa; one between California and Poland and another between California and India; and one between Canada and Denmark. Other distant places connected with points in this country included Cairo, Egypt; Stockholm, Sweden; Helsingfors, Finland; Santiago, Chile; Haifa, Palestine; and French Morocco.

NEW DISCOUNTS ON LONG DISTANCE CALLS ARE INTRODUCED

ON December 16, 1935, the American Telephone and Telegraph Company and the twenty-four Associate Companies of the Bell System filed with the Federal Communications Commission new tariffs which became effective on January 15, 1936. These schedules provide for reduced Sunday rates on interstate long distance calls, and also for reduced rates on interstate long distance person-to-person calls after 7 P.M., which apply generally where the day station-to-station rate is more than 35 cents. Similar changes in the rates for intra-state toll calls became effective on January 15, 1936, in most states.

For a number of years there have been discounts for long distance calls by number from 7 P.M. to 4:30 A.M. The new tariffs make all of Sunday a discount period, so that these reduced rates are in effect continuously from 7 P.M. Saturday to 4:30 A.M. Monday.

Hitherto there have been no discounts at any time on calls made to a particular person. Under the new schedules, with

minor exceptions, in any case where there is now a discount on number calls, there is also a discount on calls to a particular person. In addition, this discount applies to all day Sunday.

NEWCOMEN SOCIETY ELECTS WILLIAM
CHAUNCY LANGDON

THE historical work of the American Telephone and Telegraph Company has received recognition from the Newcomen Society of England in the election of William Chauncy Langdon, Historical Librarian, to its membership. The Newcomen Society is devoted to the study of the history of engineering and technology. There are a number of American members,—eminent engineers, educators, and industrial executives. Charles Penrose of Philadelphia is the Vice President for America, and C. E. Davies, of the American Society of Mechanical Engineers, is the Secretary. The Executive Committee for America consists of Leonor F. Loree, who was the founder of the American branch, George B. Cortelyou, Newcomb Carlton, and William C. Dickerman.

BELL TELEPHONE QUARTERLY



XV

APRIL, 1936

NO. 2

THE BELL SYSTEM FIGHTS THE FLOODS

FURTHER BY-PRODUCTS OF TELEPHONE
RESEARCH

BEHIND THE SCENES IN A CENTRAL OFFICE

SOME EARLY TELEPHONE PROPHECIES

Contributors to this Issue

R. T. BARRETT

Lafayette College, B.A., 1907; New York Law School, LL.B., 1909. Engaged in practice of law, 1909-1918, and in newspaper work until 1921, when he entered the Information Department, American Telephone and Telegraph Company.

JOHN MILLS

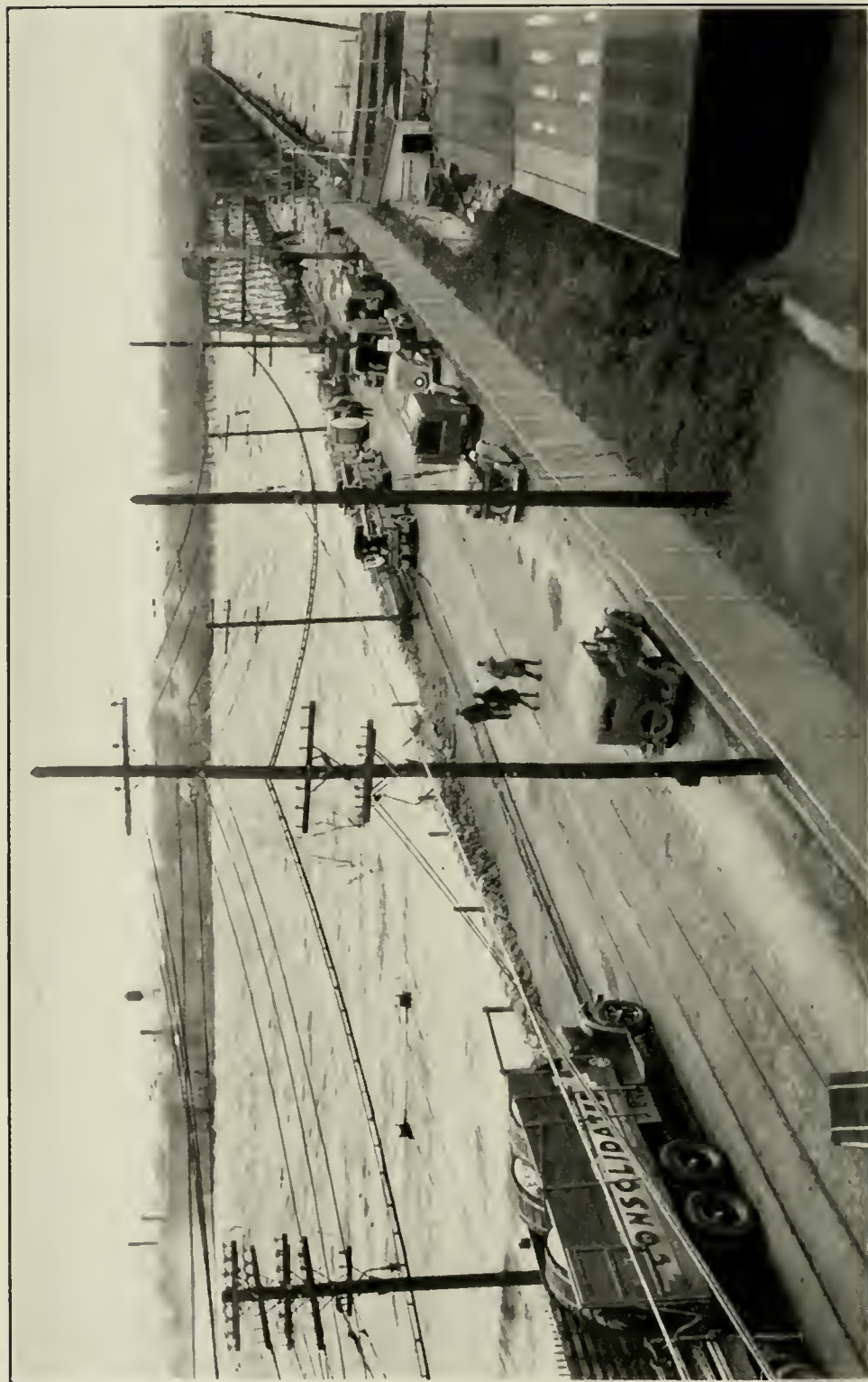
University of Chicago, B.A., 1901; Massachusetts Institute of Technology, B.S., 1909. Entered the Bell System in the Engineering Department of the American Telephone and Telegraph Company in 1911, and has been since 1925 Director of Publication in the Bell Telephone Laboratories. He is the author of "A Fugue in Cycles and Bels," and "Signals and Speech in Electrical Communication."

P. C. SCHWANTES, JR.

Western Electric Company, Manufacturing Department, inspection and inspection methods, 1918-20; Installation Department, testing methods and Methods Development Supervisor, 1920-24. American Telephone and Telegraph Company, Operation and Engineering Department, Plant Engineering Division, maintenance engineering, 1924-.

R. B. HILL

Harvard University, B.S., 1911. American Telephone and Telegraph Company, Engineering Department, 1911-19; Department of Development and Research, 1919-34. Bell Telephone Laboratories, 1934-. Since 1922, Mr. Hill has been in charge of work on development economics in the Outside Plant Development Department.



TRUCKS MOBILIZE MATERIALS AND MEN AT THE HOLYOKE-SOUTH HADLEY (MASS.) BRIDGE.

The Bell System Fights the Floods

Editor's Note:

The writer of this article has twice before contributed to the BELL TELEPHONE QUARTERLY graphic accounts of the Bell System's prompt and effective functioning, because of its integrated organizations, in meeting the challenge of wide-spread disasters. The first of these articles was "Mobilizing for the Fight against Sleet" which appeared in the January, 1925, issue and described the effects of the storm that swept from the Gulf to the Great Lakes in the winter of 1924. The second was "The Telephone's Part in the Mississippi Flood Fight" and appeared in the issue for July, 1927. The issues for April and July, 1934 also recounted the effective mobilization of the system's resources in local disasters as demonstrated in connection with destructive fires at Anderson, Indiana and Birmingham, Alabama.

MELTING snow. Spring rains. Mountain rills rising, to become streams; streams swollen into rivers; rivers transformed into rushing torrents, carrying death and destruction in their wake. The normal relationships of business and social life disrupted. A city of half a million and a hamlet of half a dozen houses attacked by forces which strike at the one and the other with tragic impartiality. Floods.

Such was the foe which, on a front extending from Maine to the valley of the Ohio, the Bell System was called upon to fight during turbulent days and weeks in the middle of March, 1936. The word *fight* is used advisedly, for here was a battle without precedent in the history of the telephone, in the issues it involved, as in the extent of the terrain over which it was waged.

The Bell System, in its long history, has faced many public emergencies. But floods are not like other catastrophes, and this was not like other floods. Fire may destroy a central office, silencing the telephones which it serves; hurricane or tornado may cut a swath of destruction across a state; a cloud-

burst may inundate a village or imperil a single city. But such catastrophes, as contrasted with this, may be looked upon as localized; here was one against which war must be waged at a hundred points simultaneously.

Floods—and floods covering wide areas in particular—are unique among public emergencies in the extent to which they disturb the human contacts which it is the function of all communication facilities to provide. Rising waters place a premium on the maintenance of telephone service, which reaches into homes, offices, factories, farms, tying them together and giving them access to physicians, hospitals, the police, the fire department and other public or semi-public agencies upon which the protection of life and property depends.

Local telephone service becomes, in such an emergency, the nervous system of an organization which must swiftly be set up to handle relief problems, to safeguard health, to prevent further destruction. Long Distance service performs the same functions, on a wider scale; provides the means of allaying the anxiety of friends or relatives of those who are within the flooded area; permits the mobilization of a nation's resources to aid the suffering or succor the needy. It is no mere catchword that the men and women of the telephone service have coined when they say, in such emergencies: "The message *must* go through!"

It must, and they know it. And they know the difficulties under which they are to work in order that it may go through. They know that, from the very nature of most of the apparatus which provides telephone service, this apparatus cannot function properly, or at all, when submerged. They know what will happen to switchboards and countless other things if the waters rise high enough. They have no illusions about what lies before them when they begin a war against floods.

Most of the credit for the victorious battle in March with rising water should properly be given to the men and women whose devotion to duty has provided some of the highlights of

THE BELL SYSTEM FIGHTS THE FLOODS

a drama enacted on a stage as wide as a dozen states. Some of it should go, however, to the vision and foresight of men who years ago laid the foundation for an integrated, unified telephone system which not only can meet the daily needs of a nation for direct, personal communication, but can mobilize men and materials for the meeting of these needs when they are augmented by great public emergencies.

THE WATERS RISE

Thanks to this integrated service, telephone people were as well prepared as men could be to meet the crisis with which they were confronted as the flood waters swept through scores of hamlets, villages and cities. In Johnstown, Pa., there were recreated scenes suggestive of the disaster of 1889—all save the loss of life. Rising waters rolled, too, into Springfield and Holyoke, Mass., moved sullenly down the valley of the Connecticut and inundated Hartford, and on to Long Island Sound. The Susquehanna and the Delaware rose above their banks; the Potomac menaced Washington itself. Water stood deep in the streets of Wheeling. Pittsburgh, Williamsport, Wilkes-Barre—in a score or more of Pennsylvania communities, as in scores more in New England, in Southwestern New York, in Ohio, Maryland, Virginia and West Virginia, the battle was on.

The full story of this struggle cannot be written. All that it is here possible to do is to touch on certain well defined aspects of the problem of providing telephone service under conditions such as these, and to see how these problems within a problem were solved.

The first of these problems, obviously, was that of maintaining the physical facilities required for the rendering of telephone service. When these fail, the devoted loyalty of operators is unavailing. Circuits had to be kept intact or, if broken, had to be mended. Or if they could not be restored to service, substitutes had to be found for them. Switchboards

had to be protected from water as long as possible, and if the water got to them, other switchboards had to be rushed into service elsewhere to take their places. Isolated telephone buildings had to be reached, food carried in for those who were there, doing duty on the firing line. Supplies of telephone equipment had to be rushed to areas where apparatus had been rendered useless. In literally scores of places these things, and many more, were being done simultaneously, by a dogged, determined army that would not admit defeat.

REPORTS FROM THE FRONT

Over the teletype at the headquarters of the Bell Telephone Company of Pennsylvania, at Philadelphia, clicked terse messages conveying vital reports and orders and also such messages as this, describing the progress of the battle:

SUNBURY, 3:45 P.M. Central office men are removing ringing machine, moving parts to upper floor of building and reassembling them. All doors and windows on first floor barricaded and sealed to keep out flood. Operators tired but cheerful. We're here to stay.

Or this, from Williamsport, where the struggle on another sector was becoming acute:

Water still coming after us. Local service still operating. Two feet more and the toll switchboard will go under. There's nothing for us to do but wait and hope.

Or this:

LOCK HAVEN, 8:45 A.M.—Six feet of water in main streets. No regular power available. Have been using automobile batteries to run switchboard for several hours. Don't worry. We can hold out as long as equipment lasts.

Or this, from Pittsburgh, on the morning of March 19:

All emergency equipment that we can beg, borrow or buy is being concentrated. Continued transportation difficulty in get-

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ting heavy stuff like emergency charging units to the stricken points.

All hands on deck everywhere. Operating forces have gotten through to their offices somehow. The men are fine. The women are magnificent!

Over teletypes in Boston and New Haven and New York and Washington and Cleveland similar bulletins were being received, almost in an unbroken flow, save when telephone people on the firing line were too busy doing things to stop to tell what they had done.

In Western Pennsylvania, the menace to telephone plant was complicated by other evidence that when Nature turns outlaw, she never does it by halves. Twenty-four hours before flood waters began to reach dangerous stages, the entire northwestern portion of the state was swept by a serious storm. As if opening her battle against the telephone forces with an artillery barrage, Nature hurled a salvo of sleet. Ice freezing on wires and crossarms, accompanied by high winds, snapped off more than 800 poles between sunset and sunrise, and put 175 toll circuits out of service. With the service-restoration problem arising from this wholesale destruction of plant, the telephone men of Pennsylvania were struggling when the floods struck, on a dozen fronts at once.

In Central and Western New York, the telephone forces had to fight not only floods and sleet, but snow. In and around Buffalo the snowfall was one of the heaviest of the winter, while sleet swept the eastern end of the central portion of the state. The Susquehanna and Chenango rose and swept down upon Binghamton. Elmira plant men had a battle on their hands with both flood and sleet. In dozens of other towns, telephone men and women found themselves facing a combination of foes which called for all they had of courage, fortitude, endurance and resourcefulness.

After the peak of the flood on the Ohio had done its worst in Western Pennsylvania, it swept on down the valley to

Wheeling, where plant forces of the Chesapeake and Potomac Telephone Company were waiting for it, ready to fight it to a standstill. Every resource of plant or personnel which they had at their command was thrown into the struggle. Cable gangs were called in from other points in West Virginia to speed up the work of restoration as soon as the recession of the waters made this work possible. Meanwhile, as elsewhere, sandbags were piled around entrances to telephone buildings, doors were barred and sealed to prevent the entrance of the flood waters to lower floors, pumps were started and kept going without pause until the emergency had passed, all to the end that equipment might be kept in operation.

In Virginia and Maryland, rivers rose far above normal stages. The James was nearly twenty-five feet above the mean level at Lynchburg. There was high water at Richmond. The Shenandoah Valley felt the force of the rising waters.

Wherever the battle was being fought, the first concern of telephone men and women was to keep open the lines of communication to the police and fire departments, the Red Cross, the hospitals, the WPA relief stations, and the offices and homes of physicians.

In a few cases it was necessary, when the flood was at its peak, to restrict telephone service to these essential points and other emergency stations in order to conserve current from storage batteries which had been cut off from their usual source of power. Indeed the loss of current in these and certain other cases, occasioned by the flooding of the power company generating stations, was one of the serious problems which telephone men had to face. It became necessary quickly to set up emergency power equipment and the shifting of equipment of this character and of other supplies from one area to another, affords a striking illustration of the advantages of an integrated system which makes this mobilization of materials possible.



1. Severe sleet storms swept Northwestern Pennsylvania just prior to the floods.

2. Ice-jammed Kennebec River, Richmond, Me.

3. Holyoke-South Hadley, Mass., bridge. (See frontispiece. Note the broken cable at lower left corner.)



4. *Business office at Hartford after water had partly receded.*

5. *Barn resting on a telephone cable in Connecticut.*

6. *Up to cross arms of an A. T. & T. toll road, Ohio.*



7. *Water pouring into basement at Hartford.*

8. *High water mark at entrance of Sterling office, Pittsburgh.*

9. *Telephone office at Bridgeport, O., is on second floor of corner building.*



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Through night hours, trucks rolled along Connecticut roads converging on Hartford with their burdens of emergency equipment which meant life to a city's telephone service. Powerful engine-generators were brought from as far away as cities in New Jersey and from west of Syracuse, New York.

In the rest of New England in the states where the New England Telephone and Telegraph Company operates and in upstate territory of the New York Telephone Company, similar scenes were enacted. Wherever power failures were experienced or seriously threatened, engine-generators were moved in either from other offices or from warehouses.

On Pennsylvania roads leading toward Pittsburgh and other stricken cities, other trucks, bearing similar burdens, were enacting similar roles in the drama of the Bell System's battle to keep its service intact. Heavily laden, hampered by roads which at places were covered with water or which had turned to mud, they went rolling doggedly along—caissons in the field artillery of a far-flung peacetime battle.

THE SERVICE OF SUPPLY

One of the dramatic chapters of the history of this war against rising waters, if this history is ever written, will be that which recounts the exploits of the men of the Western Electric Company in maintaining the "service of supply" which helped to make victory possible.

A great battle is a test, not alone of the stamina and the spirit of those who engage in it, but of the strategy of those who have planned it. To such a dual test the supply system provided by the Western Electric Company was subjected in this most acute and most widespread communication crisis with which it had ever been confronted. That it stood this test is apparent from the fact that, faced by the necessity of making the largest emergency shipments of telephone supplies and equipment in the history of the telephone in America, it made these shipments with a speed and an efficiency which have never been surpassed.

In order to meet such situations as this, as well as to handle efficiently the demands of everyday telephone construction and maintenance, the Western Electric Company maintains, at strategic points throughout the country, warehouses well stocked with stores of supplies and equipment which may be drawn on at a moment's notice. It had made preparation for the floods of this Spring, for conditions had indicated, in advance, that there was likely to be high water. Special stores of emergency supplies were in readiness. The first flood warnings were the signal to the crews of these warehouses, and to those of the company's three principal factories at Chicago, Baltimore and Kearny, N. J., to hold themselves in readiness for immediate action. Directed from headquarters at 195 Broadway, New York, all locations likely to be involved in the emergency were put on twenty-four hour duty. At Philadelphia, New York, Brooklyn, Washington, Boston, Newark, New Haven, and at Pittsburgh—itsself in the center of one of the most serious of the battle sectors—Western Electric warehouses became scenes of intense activity, while those as distant as Atlanta, Detroit, Chicago and Cleveland held themselves in readiness and dispatched material as called upon.

From these depots of the Bell System's "service of supply," tons of material, made up of literally hundreds of items, were shipped in an unbroken stream during the days and nights when the emergency was at its height. In warehouse and factory alike crews worked in continuous shifts and in some of the factories, during this peak of demand, normal output was more than doubled. Engineering, warehousing, service and traffic experts wheeled into action, bending every effort to expedite the movement of supplies and equipment to the point where they were needed.

As purchasing department for the Bell System, the Western Electric Company obtains from outside manufacturers large quantities of supplies which it does not itself manufacture.

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Many of these were required to meet emergency demands in the flooded areas. These concerns were notified to hold themselves in readiness, and when the orders began to roll in, they turned to and contributed their part to the winning of this war against rising waters.

ENORMOUS EMERGENCY SHIPMENTS

During the seven days when the floods were at their most critical stage, the supplies shipped to telephone companies in the flooded areas reached astounding proportions. Among some of the major quantities were more than 50,000,000 conductor feet of rubber-covered wire; nearly 24,000 telephones; 750,000 pounds of copper line wire; 200,000 pounds of pole line hardware; twenty-three sections of central office switchboard and scores of private branch exchange boards. Cable, conduit, crossarms, telephone poles or rubber boots—whatever was needed, when and where it was needed, was sent on its way from warehouse or factory without a moment's unnecessary delay.

At noon, Monday, March 23, Boston advised Western Electric headquarters at New York that it needed at once twelve P.B.X. boards of the 750-A type, in addition to ten already ordered. Headquarters canvassed nearby Western Electric warehouses. Simultaneously, it obtained a five-ton padded furniture truck on which the boards could be carried without first packing them, thus saving valuable time, and by 5:45 P.M. it was on its way with the twelve boards and five others, reaching Boston at nine o'clock the next morning.

From the morning of March 18 up to March 25, the Point Breeze plant shipped more than 600 tons of emergency material into various flood areas. Late on March 19, Pittsburgh placed an order with this plant for special armored submarine cable. This had to be manufactured, from the ground up. The cable left the plant at noon, March 22. The reel, weighing 14,000

pounds, was so wide that a special truck was required to accommodate it.

The history of the Bell System's service of supply contains few more inspiring chapters than that which tells of the stubborn battle of the crew of the Western Electric Company's warehouse in Pittsburgh against the waters which swirled around and through this outpost on the firing line in the battle against the floods. A number of warehousing and service experts were rushed to Pittsburgh from other points by airplane, and with their aid the regular crew fought desperately to keep the service of supply from failing. Finally the rising waters cut off power, heat and light and completely isolated the building. After thirty-six hours of continuous duty, the crew were obliged to retreat temporarily, leaving the building in a rowboat from a second-story window. But the retreat was only temporary. The next day a crew of seventy made their way back and again began making shipments—through the same second-story windows, using boats as their means of transport.

THE TRANSPORTATION PROBLEM

One of the major problems faced by the service of supply was that of transportation—a further illustration of the difficulty of dealing with flood conditions affecting wide areas. At the very moment when rapid transport became indispensable, transportation facilities were disrupted. Railways were crippled; paved highways were under water and dirt roads so softened by rains that they afforded no practical detours for routes made impassable by the floods; bridges were out; many air transport fields were transformed into inland lakes. To meet such emergencies as this, as well as to provide an efficient method of handling normal transport problems, the Western Electric Company maintains a staff of traffic experts. When the first demands for the mobilization of men and materials began to come in to headquarters, this staff of highly specialized transportation experts went into action. Reports on highway con-

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ditions and railroad schedules were collected; the best available methods of transportation and the shortest possible routes were selected; every possible method of carrying men and materials, from where they were to where they were needed, was brought into action.

RAILWAY FLIERS CARRY FREIGHT

There was one case in which the Broadway Limited was held five minutes in order that an engineer of the Western Electric factory at Hawthorne, near Chicago, could carry with him, as excess baggage, a shipment of apparatus which had to make the first train into Pittsburgh. Crack railway fliers, such as the Spirit of St. Louis, pulled out of stations with freight cars sandwiched in between their luxuriously appointed sleepers or coaches. In five days 218,300 pounds of telephone apparatus was delivered to the flooded areas on passenger trains.

So, on a score of sectors, the telephone service of supply continued to function. Materials by tons were moved up to the firing line and men by hundreds were mobilized to assist in the installation of these materials where they were most needed.

This mobilization of the Bell System's manpower in a crisis presented by a great public emergency is, incidentally, a convincing demonstration of the value of "One System, One Policy, Universal Service." By reason of the standardization of equipment design and of construction and maintenance practices, a Bell System plant man, anywhere, can be moved to any point at which he may be needed, at a moment's notice and will find, when he arrives, that he is as thoroughly familiar with the job which he must do as if he were doing it at home.

MOBILIZATION OF MANPOWER

And moved they were, by dozens and scores, these men of the telephone service, to help their fellows on the firing line fight the floods which had become their common enemy. From Philadelphia, early in the opening stages of the battle which

was fought over the western part of Pennsylvania, came this terse teletype report:

Twenty-five line crews, with full equipment and motor vehicles, on way from here to Harrisburg. From there they will go to stricken districts as fast as possible.

Elsewhere, in New England, in New York, in Ohio and down in the valley of the rapidly rising Potomac, other crews of reserves were being mobilized and moved up to the front. They were sent into the Pittsburgh area from as far east as New Jersey, from Ohio and from as far west as Detroit—they could as easily have been sent from California if there had been means of carrying them to the flood areas swiftly enough to make such a mobilization practical.

A further example of the mobilization of the Bell System's man power to meet emergency conditions is afforded by the contributions of members of the General Staff of the American Telephone and Telegraph Company and of the Bell Telephone Laboratories. At Pittsburgh, Williamsport, Hartford and other points, these technical experts were quickly on the ground and assisting on many urgent engineering and operating problems. For example, important decisions had to be reached on such matters as to whether apparatus which had been submerged could be made to function properly if dried out or whether new equipment should be installed. Also technical advice was needed as to the best methods to be followed in restoring such equipment, where practicable, to working conditions. Assistance was likewise rendered in some cases in connection with emergency power facilities and testing arrangements.

LONG LINES IN ACTION

While crews of the Bell System operating companies in the territories affected by the floods were struggling to maintain local service, and toll service within their own areas, other crews

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of the Long Lines Department of the American Telephone and Telegraph Company were putting up an equally courageous and equally successful battle to keep long distance lines in operation. Even while the flood waters were at or near their peak in many localities, these Long Lines gangs succeeded in restoring ninety-six per cent of the long distance circuits which would normally have been in service. During the whole period of the flood, Williamsport, Pa., was the only city of any considerable size which was totally cut off from voice communication with the outside world, and long distance circuits into that city were operating by Saturday, March 21.

Long Lines men working in boats repaired the Albany-Springfield cable which was carried away by ice and debris when the flood waters rose to record heights at South Hadley Falls, Mass. Incongruously enough, at almost the same time, repair gangs at Hartford were also working in boats, but inside the telephone building, to repair a long distance cable which had gone out of service.

Long Lines test boards everywhere became scenes of intense activity. The long distance traffic control bureau in New York, during the six days when flood conditions were most serious, issued about 1000 "patch orders" by way of providing substitutes for circuits which had been put out of service. The normal average of such orders at this bureau is about ten a day. In Cleveland, O., where more than four or five "patch orders" a day would be looked upon as exceptional, a hundred or more were issued during the emergency period, and at Chicago the increase was correspondingly high.

CABLE NETWORK PROVES VALUE

Tested by the rising waters, along with the endurance and fortitude of Bell System's personnel and the reliability of its plant, was the policy which has made such dependable plant available. This fact was convincingly demonstrated by the

manner in which the local and long distance telephone cable network withstood the severe conditions to which it was subjected throughout the entire flood area.

When aerial lines were torn out by rushing water or floating ice and debris, or were snapped by sleet, as scores of them were in northern Pennsylvania, long distance telephone cables continued to function. Many of them remained in service although they were submerged for days.

In several cases, even these cables were in danger of failing, due to the battering their heavy lead sheaths received from trees, ice and other floating debris. To keep the water from entering the interior of cables in which leaks were caused by these conditions, nitrogen gas, under pressure, was forced into the cables. The slow escape of this gas, through any breaks in the sheath that might be thus caused, prevented the water from entering. To meet the demand for nitrogen, containers of the gas were shipped from distant points by airplane.

Not only was the American Telephone and Telegraph Company able to maintain a high percentage of its own long distance service during the emergency, but also provided valuable assistance to the telegraph and railroad companies by furnishing them with telegraph and telephone circuits through its cable network. At the maximum, the American Company was furnishing other communication companies with a total of more than 53,000 miles of wire.

LONG DISTANCE TRAFFIC MOUNTS

Long Lines traffic in many areas rose far above normal levels. At most points throughout the flood regions, double the normal number of long distance operators were on duty at the switchboards, struggling to give prompt service on the flood of emergency calls that swept through their offices. On Sunday, March 22, the Long Lines traffic at Buffalo was 118 per cent above normal; at Pittsburgh, 219 per cent; at Cleveland, 134

10. Hartford operators hard at work at the toll board and—

11. Turning in for the night on cots and settees in an improvised dormitory.



12. A two-ton cable reel going into a Hartford window.

13. Catwalk bridge which saved the situation for Hartford folks.

14. The public made emergency long distance calls in the Pittsburgh business office by lantern light.



15. Power units were rushed to the flood areas from far-distant points.

16. The Pittsburgh "Light Brigade" goes into the flood battle.



17. Festoons of "twist" decked the streets of Williamsport.



18. A "home-made" ringing machine in Sunbury, Pa.

19. The test-boards at 32 Sixth Ave., New York, became battle sectors as "patch cords" helped carry the mounting traffic to and from the flooded areas.



per cent; at Philadelphia, 67 per cent. The traffic out of New York to certain points was at times as high as 400 per cent above normal and emergency calls were so heavy that for the entire flood period the average traffic load in New York was more than fifty per cent above normal.

Emergencies such as these floods naturally tend to overload telephone facilities not only in flooded areas but in other places through increases in toll business. Plant is installed for reasonable engineering periods, so if adequate facilities are to be available for business expected within the period, there is, on the average, even under normal business conditions, a certain amount of margin over and above current needs. These margins have frequently been found helpful in time of emergency. Similarly during this flood emergency it was possible to make effective use of much of the present plant margin which is larger than usual because of the loss of business during the depression.

In Associated Companies, in the Long Lines Department, in the Western Electric Company, in the Bell Telephone Laboratories, and in headquarters at 195 Broadway, New York, the battle went on. From Maine to Michigan; from Vermont to Florida; from men filling quantity orders for rubber boots to other men shipping equipment by plane; from line crews climbing poles to scientists grinding crystals, every man was in his place, doing what he was called upon to do, and doing it as swiftly and as surely as long years of experience had taught him to do it.

But what of the women of the telephone service?

Coördinate with the problem of maintaining telephone facilities during an emergency is that of keeping them in operation, and this is a task for which a large share of the responsibility rests upon the women of the switchboard. It is almost superfluous to say that the telephone women of the flood areas responded to this responsibility with a devotion and loyalty that

were nothing less than heroic. But let us return to the teletype machine in telephone headquarters at Philadelphia, which we have already watched as it has clicked off its brief, almost matter-of-fact chronicle of what was going on along a battle front where women and men were fighting desperately to keep a vitally important communication service from failing when it was most needed.

“THEY KEEP RIGHT ON ”

From Johnstown, at eleven o'clock on the night of Tuesday, March 17, comes this message:

Water still rising around us. Has reached stair landing just outside central office door. All ten operators still at the boards, putting through every possible call. They are magnificent. They know they are in a ticklish spot, and they keep right on. It's nearly freezing cold here. The water is moving at a terrific rate and is roaring past the office with so loud a noise that it is hard to hear the voices over the telephone.

From Williamsport, the next morning:

Water at twenty-seven foot stage and within five feet of the level of the toll board in center of city. Traffic very heavy. Operators carrying on grand style. Ditto everybody else.

From other sectors along the battle line, from Maine to the Ohio, came similar stories of the part women were playing in this drama of the fight with rising waters—women at small, one-position boards serving hamlets or villages, who fought their battles single-handed; women who fought in groups, but not less valiantly, in the larger cities; women who remained at their posts of duty until, in some cases, the water finally won and their equipment became useless, and who only then retired from the field, to return once more at the earliest opportunity.

So one might have seen, at Hartford, a company of a hundred operators grimly plugging up connections, hour after hour, while on the ground floor men were fighting a gallant battle to

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keep the water out of the equipment. Hour by hour the traffic mounted, as emergency or relief officials directed the battle to save the city from the menacing waters which filled its streets. Girls from the business offices volunteered to help carry the load at the switchboard by passing toll tickets, and in other ways gave the weary operators a chance for brief periods of rest. Cots were brought into operating rooms or rest rooms, and on these—or on tables or on anything else which could serve for a bed—the tired girls lay down to snatch what they could of rest.

In other cities and towns throughout the flood areas, similar scenes were being enacted. It is impossible, in an account of this character, to record individual names of telephone women and men who distinguished themselves, or even to list all of the localities in which telephone people did heroic service.

GETTING FOOD TO THE FIRING LINE

But what a picture of one sector of this battle with the floods is presented by this teletypewriter message, dated from Johnstown at 8:35 A.M. on March 18:

Thanks for the boat. Train stopped four miles from city, boat hauled balance of way. Just had food brought in—first since yesterday noon. Girls' appetites good as ever—and they appreciate the blankets.

Which suggests a brief digression. One of the problems involved in maintaining telephone service in these isolated central offices was that of getting food and other comforts into the buildings for the use of those who were doing duty on the firing line. In Johnstown, as in many other places, it was done by boat. In Hartford, a steel cable cat-walk bridge was strung across the street between the Pearl Street building and the isolated Trumbull Street building, and over this swaying bridge there moved an almost steady stream of men, women, materials and supplies. Over it were carried thousands of hot

meals and gallons upon gallons of hot coffee to satisfy the hunger and to revive the waning energies of the hundreds of men and women who were at work in the water-bound building. Girls from all departments of the telephone company volunteered as emergency members of the cafeteria force. Dozens of them washed dishes from Friday to Monday. Other sources of heat having been cut off by the rising waters, plumbers' furnaces, commandeered from the plant department, were used to boil the water for dish washing.

Throughout the flood areas, scores of operators and other girls, who were off duty, voluntarily came back to work because they knew they would be needed. Often operators made their way to central offices under difficulties which would have turned back women, or even men, with hearts less stout. One of these was a chief operator in an Ohio town, whose home was in another community, some distance away. High water swept over the highway and the interurban railway connecting the two towns. In an effort to reach her central office, the operator took one of the last of the interurban cars to attempt to make the run between the two communities. It was stopped by the flood.

OVER ICE-COVERED RAILROAD TRESTLES

She asked if there was not some way by which she could get through. While others were turning back, she made her way over a route which took her over open fields, through snow that was knee-deep, to a railway track. Over its ice-coated rails and ties she walked, crossing several trestles beneath which rushed the swirling flood waters. At some points, the water was so high that, as she passed over these trestles, she could have dipped her feet into it. After more than a mile of such hazardous travel, she reached the central office. She and her force of six operators, augmented by three volunteers, kept at their post until the emergency had passed.

Nor was this spirit of loyalty to the public interests manifested alone by women who are now telephone employees. In every great emergency, scores of former operators offer voluntarily to return to the switchboard. So it was in the emergency which has just passed. A woman who for fifteen years was an operator at Norfolk, Va., called up telephone headquarters in Philadelphia, where she now lives with her family, to offer her services in the flood stricken areas. "I'd like to do something to help out—anything at all," she said. "If you need me, please call and I'll be ready. I'll go anywhere."

What is this thing which prompts a woman to walk ice-covered trestles in order that she may reach a place where she knows that she will be called upon for long and arduous and perhaps hazardous duty? What impels an ex-operator to volunteer to return to the switchboard—to say that she "will do anything" or "go anywhere"? When Arthur Lamare, a lineman of the New England Telephone and Telegraph Company, was swept to his death while crossing the Williams River near Bellows Falls, Vt., with three other telephone men, in order to do an emergency job, what was the motive which prompted him thus to face danger in the performance of duty?

"THE SPIRIT OF SERVICE"

The men and women of the Bell System have come to call this "The Spirit of Service." They cannot define it. Nor can anyone else. It is not something to be described by words; it is something to be lived. It assumes concrete and understandable form only when men and women do the things which telephone people do in great emergencies because they know that for the doing of such things there is a vital human need.

And out of the Bell System's battle with the floods has come a full measure of recognition of this spirit. It is here possible to include only a few typical expressions.

On the stub of a bill returned, with a check, from a woman subscriber in Pittsburgh was written this brief but expressive sentence: "Congratulations on quick return to service, after the flood."

From this terse tribute, by an individual subscriber who wished to express her gratitude for the prompt restoration of service in her home, to much more formal expressions, the letters poured in. They came from public officials, heads of relief organizations, business executives, professional men, heads of hospitals—from all sorts and conditions of men who had, in short, seen what telephone people had done during the flood and who wished to thank them for it.

"UNBELIEVABLY HELPFUL"

The chairman of the Pittsburgh Chapter of the American Red Cross wrote:

I have already told you, and I intend to repeat it on every possible occasion, the deep appreciation that the Red Cross feels for the unbelievably helpful attitude which the telephone company has taken during the recent disturbance. Specifically, however, I would like to say a word about the trouble-shooting crew which you had in the Community Fund Building since the flood started. Hardly an hour of any day passed that we did not make some request of these men, and in every instance we were met with courtesy and, what is more important, I don't think there was a time that we failed to get what we wanted from them.

Some of the letters received spoke not alone for their writers individually, but on behalf of the people of entire states. Thus the governor of New Hampshire wrote to the President of the New England Telephone and Telegraph Company:

It is almost impossible for me to express to you the personal appreciation I feel and the appreciation I know the people of the State of New Hampshire feel for the services you gave us throughout your organization during the period of the recent disaster.

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Every means at your disposal was made available that the State could better combat the disastrous sequence of events which came upon us so rapidly and with so little warning.

Your company and its employees performed a great service at a time when it was most needed. This performance saved hundreds of lives and an untold amount of property, both public and private.

It would be difficult to extend appreciation individually to each of your employees who worked at their posts during the flood. Please convey to them my deep appreciation for the services they performed and the gratitude of the people of New Hampshire whom they served so well.

TRIBUTES IN THE PRESS

Not less outspoken in its praise of telephone service, and of the men and women who provide it, was the press. In large cities and small villages, from great dailies to struggling weeklies, the newspapers of the flooded areas, and of the nation as a whole, paid high tribute to the devotion which made possible the maintaining of a vitally important communication service. Said the Portland, Me., *Evening Express*:

Telephone operators are proverbially faithful to their jobs, but the devotion and courage of these Rumford girls was one example of the heroism and devotion that most men and women show in times like this . . . there is probably not an exchange in Maine, or in the country, for that matter, the workers of which would not have done the same thing.

Said a special writer in the Erie, Pa., *Dispatch Herald*:

Probably one of the largest groups of unsung heroes in the time of disaster are the telephone employees. They are the last ones to leave their posts and far too often they don't leave until it is too late for them to escape the fury of the flood or the crumpling of the walls in an earthquake or tornado. . . . It is the law of all communication companies to give the best service at all times as long as it is humanly possible. This slogan will be found on the wall of every branch of the great Bell System.

From the *Record* of Plymouth, N. H., comes this summary:

Again and again during the past week we heard praises sung of the local telephone operators and their splendid work. . . What a wonder it was that we did not lose the telephone. All through the two floods we were in touch with the outside world.

Under the caption "Heroines of the Flood," the *Daily Intelligencer*, of Doylestown, Pa., published the following editorial:

Among the heroes of the flood whose praises have been sung, very little has been known, perhaps, of the extent of the heroic service given by telephone operators and maintenance crews that stuck to the last in their effort to give service in an emergency when it was most needed and most difficult and dangerous to maintain.

The "log" of the bulletins received from various points by the Bell Telephone Company is an enlightening testimonial of the desperate efforts made by the employes to keep the service going to the last minute possible—even though the lines were being operated on the emergency batteries or "the water was within four feet of the operating board," and operators were working in the dark and chilling cold.

"We are going to stick as long as there is a telephone in service" is one bulletin quoted from Punxsutawney at 4:25 a.m., the zero hour so far as courage is concerned for most persons.

It was through these heroic operators, mostly girls, that the world outside was kept acquainted with the terror and destruction and need that existed—hastening the arrival of the rescue crews.

But it was all in the line of work for these courageous employes with their high sense of duty.

The *Spectator* of Somerset, Massachusetts, published the following tribute to the telephone organization:

Ordinarily we take the modern telephone's marvellous convenience without a thought. But for the way in which this service struggled through the flood's devastation we owe an expression of gratitude. This gratitude must take into account the individuals, official and employee, who worked so hard, answered



Typical problems which confronted telephone plant crews:

20. Concord, N. H. (Boston Traveler Photo). 21. Toronto, O. 22. This International News Photo shows a line in Maryland. 23. At Westminster, near Belloxys Falls, Vt.





After the water had receded:

24. A PBX at Cumberland, Md.

25. Mud-coated telephones at Williamsport, Pa.

26. An installer trying to find working pairs at Pittsburgh.

27. Ruined cable duct on bridge at Montgomery, Pa.

28. Inside the Western Electric warehouse at Pittsburgh.



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so patiently, explained so clearly, surmounted so many unguessed obstacles, to put our message through. They did a splendid job; the swiftness of their repairs since the flood has been equally notable. In order that they might serve us they did something more than we pay them for. They deserve our unstinted thanks.

And in this outpouring of generous sentiment there appears, further, a recognition that the demands upon telephone service that are generated by emergencies are different from those of day-to-day routine only in degree, not in kind. It is indeed true that flood, fire and tornado merely hold, as it were, a magnifying glass over a nation's daily need for dependable telephone plant and devoted telephone personnel. Telephone equipment functions dependably under abnormal conditions because it has been brought nearer and nearer to perfection through long years of development to meet the needs of normal conditions. Telephone men and women rise to meet extraordinary demands because they have learned to meet ordinary demands effectively.

The testimony of flood sufferers is yet being voiced and written. It must be pleasant reading to the Bell System personnel concerned, for it is good to be endorsed by the testimony of eye-witnesses—by those who know. But there were those who were not eye-witnesses, yet who knew just as accurately as though they too had been on the spot. They were other telephone people, who had met the challenge of hurricanes in Florida and earthquakes in California, of floods in the Mississippi Valley and cruel sleet storms in the Northwest. They knew what would be done before it was done because it was what they would do themselves. Ask them their verdict and it would be expressed in a single phrase—"A real telephone job."

R. T. BARRETT

Further By-Products of Telephone Research

Editor's Note:

This is the second of two articles by members of the staff of the Bell Telephone Laboratories that discuss the effect of telephone research on social and business activities outside of the communications field. In the January issue of the QUARTERLY, Mr. Steinberg told of the aids to those of impaired hearing that resulted from this research. In the following article Mr. Mills writes of the new amusement arts that have similarly resulted.

ANY basic invention—and it is particularly true of the telephone—opens the way for thousands of succeeding inventions which perfect the originally crude mechanism, extend and elaborate the principles of its operation and develop application of these principles to uses far removed from that of the original invention. An expanding field of application is inevitable; as the invention is perfected, new arts arise and older arts profit by the new techniques and instrumentalities. With each improvement in the device of the original invention, further possibilities for its application become evident. As knowledge of the device and of its physical principles becomes more widely disseminated, and as these principles become more generalized and less specific, applications increase in variety and importance.

The moment, for example, that Dr. Bell invented the telephone—the electrical system which permits oral communication—it became inevitable that the system should be extended to permit more than a single person to listen to a distant speaker. This could be accomplished by providing at one end of the line either a number of receivers in multiple, so that each reproduced for its listener the speech which the transmitter picked up at the other end, or a single more powerful re-

ceiver which could radiate the sound to a group of persons assembled before it. In either case the physical principles of Dr. Bell's invention permitted what today we would call "public address."*

The possible use of the telephone in a public-address system was early recognized, as was also the fact that it might transmit music for the esthetics of its sound instead of speech for its content of information. Commercial application of these ideas lagged far behind their recognition for two main reasons. In the first place a much larger amount of energy is needed at the receiving end of a telephone circuit if a loudspeaker type of receiver is used which must spread the energy over a considerable space. This makes desirable some amplifying means for increasing the energy available in the loudspeaker; but there was no basis for amplifiers for the public address until the telephone repeater was developed.

The second reason that public-address systems followed by as many years as they did their underlying basic invention has to do with the acoustic quality of speech. Each syllabic sound of speech is composed, in effect, of a number of pure tones; and its speech significance, its individuality to correspond with the speaker and its emotional content are due to these separate tones and to the relation of their intensities. Of these tones the pitch range which the ear can appreciate extends from about an octave below middle C to about five octaves above. Such a wide pitch range, however, is not necessary for the ordinary purposes of telephony where it is sufficient if the reproduced speech is easily intelligible and is also sufficiently natural so that voices can be easily recognized.

Where music and high quality speech (i.e., program) transmission over loudspeaker systems is involved, very exacting

* The use of the term "public address" in this article reflects historical usage. The term as used today applies to privately owned amplifying systems available for use in auditoriums or at large outdoor gatherings. Such "public address" systems may be connected with program transmission facilities provided by the Bell System but not with the regular local or long distance lines.—*Editor*.

requirements are placed on all parts of the telephone lines which serve the loudspeakers. Whereas in ordinary telephony the requirement is primarily that of good intelligibility of speech sounds, in the use of loudspeakers for musical reproduction naturalness becomes highly important. Today, for example, a range of pitch up to 2800 vibrations per second is very satisfactory in telephony, but is esthetically inadequate in a public address system or in a radio broadcast. Chain broadcasts radiate up to 5000 vibrations, or more, per second although home radio sets may not deliver to their auditors all of that range.

The element which made the public-address system possible, and also provided apparatus and techniques for radio broadcasting, is the telephone repeater. This device was necessary to long-distance telephony. Since speech currents weaken progressively as they travel a telephone line it was soon obvious to those engaged in the art that some device was needed which could receive these currents at the end of one stretch of the line and start out on the succeeding stretch an amplified repetition of them. With such devices installed at successive points along a line there would be practically no limit to the distance over which a telephonic message could proceed. Further, of course, since lines in which the currents weaken least per mile of travel are in general the most expensive, the use of such telephone repeaters would permit the use of lower grade and more economical lines. The long-distance telephone plant of today owes its geographical extent and much of its economy to the successful development and operation of the vacuum-tube telephone repeater.

Without this repeater, or, more strictly, without its amplifying element and auxiliary equipment, public-address systems would have been very limited in range. The repeater was designed to receive speech currents from a line and to supply similar currents of greater energy to the next section of line. Instead of supplying the amplified currents to another

stretch of line, it could serve at the terminal to supply amplified speech currents to a powerful loudspeaker. The current which is to be amplified is a complex one, containing component currents for each of the tones in the speech it bears. In the amplified current there must be similar components but all proportionately strengthened so that the relation of intensities of the component currents is not altered.

The first practical and large-scale utilization of telephonic apparatus and techniques for public address occurred early in 1912 in Chicago, where Yale alumni at a dinner were addressed by their President Hadley from his home in New Haven. They listened through individual head receivers. The amplified current to supply so many receivers came from two telephone repeaters. These were of the so-called mechanical type and consisted in substance of a receiver element and a telephone transmitter element so arranged that speech currents in the receiver operated the transmitter to initiate similar but amplified currents. This device, which was soon to be succeeded by the vacuum-tube repeater, had already performed with some success on long-distance lines.

Public address through multiple receivers reached its peak in number of listeners during the year or so following the opening on January 25, 1915, of the New York-San Francisco telephone circuit. In that pronounced extension of the distance range of telephony—New York-Denver had been the previous limit—the telephone repeater was a vacuum-tube device, developed during the preceding three years in the Bell Laboratories. Demonstrations of transcontinental telephony were made for business and professional groups in a number of places near one or the other of the two ends of this circuit. The largest participation occurred at a meeting of the Telephone Society of New York, where 3250 receivers were provided. Nine hundred members of the corresponding organization in Philadelphia were similarly equipped, 1200 in

Baltimore, and 1000 in San Francisco. These four groups were interconnected, so that all heard the same program, parts of which originated in New York and other parts in San Francisco.

The steps between public address through multiple receivers and public address with more complete reproduction of the speaking voice through loudspeakers, necessarily awaited research studies on all the related problems of the pick-up of sound, its conversion into equivalent electrical currents, its transmission, distortionless amplification, and distortionless reproduction. These problems, of course, have been the subject of continuous study on the part of telephone engineers and scientists ever since the work of Dr. Bell. His invention of the telephone had come, in part, from his recognition of the fact that for telephony it was necessary to produce an undulatory current corresponding to the wave character of the spoken word. He started the investigations which have continued ever since into the character of speech. This is the commodity which the telephone system transmits and reproduces, and it was always well recognized that it was basic to doing a good job in telephony to know with precision the character of the commodity. Telephone lines should obviously be designed to transmit those tones of human speech which are essential to the purposes of telephony; and, similarly, transmitters should be designed to pick up and faithfully convert into components of current all these essential tones, and the receivers faithfully to reproduce them in sound waves.

Transmitters and receivers can be designed which will very accurately and faithfully translate complex sound waves into waves of electricity, and vice versa, but, in general, they are relatively insensitive because they obtain quality at the sacrifice of efficiency. Such precision instruments, however, were not practicable until near the end of the fourth decade of telephony, when the development of the vacuum-tube amplifier

permitted their development. Insensitive but distortionless transmitters and receivers then became practicable because the tube could be used to amplify the feeble current from a high-quality transmitter or to supply amplified current to a high-quality but somewhat unresponsive receiver.

This possibility, which the vacuum tube introduced, was immediately capitalized in Bell System researches. Because it is fundamental to the telephone business to know all that can be found out as to what are the component sounds of speech and as to what is the hearing ability of the ear for such sounds, the Bell System has always been concerned with speech and hearing. The development of the vacuum tube gave power to those researches. Coincident with its development, a large-scale program of intensive research was initiated. In order to investigate the operation of the ear, special telephone receivers were designed which would deliver to it without distortion tones of a wide range of pitch and of a wide range of loudness. For these experiments, the vacuum tube was made to operate as a generator producing alternating currents of any desired frequency and hence corresponding to tones of any desired pitch. Auditory ability was thus mapped out for the entire range of pitch and of loudness of which the ear is capable.

In the analysis of speech, the research investigators set themselves the task of picking up telephonically all the component sounds of speech and of converting them faithfully into corresponding components of current. They planned, in other words, to construct devices so perfect that even the keenest ear could not find a flaw in their rendition, and then, by controlling the current through electrical filters or other circuit elements, to introduce measured amounts of imperfection until an observer could just detect a fault. In that way they expected to reach a quantitative understanding of the importance of the various component sounds of speech. These investigations necessarily carried somewhat into the field of music, where

they produced important information. The clear knowledge of the nature of sound that was derived from these studies, which have been continued ever since, has been an important factor in the improvement in the quality of telephone conversations in recent years; and it has been the basis of the enormous advances which have been made in public-address systems and in the related fields of phonographic reproduction of music, of sound-motion pictures, and of radio broadcasting.

Instruments of remarkable precision were required in the conduct of these investigations, because if the scientists were to measure the smallest detectable variations in sound, they had obviously to use equipment which was capable of a degree of exactness beyond those small quantities. The instruments which they developed were necessary to their investigations, but they quickly found other important uses. A telephone transmitter—technically known as the “condenser” type—which was developed in the early stages of those studies served in the application of telephonic techniques to the production of phonograph records. And that same microphone became the “mike” in radio broadcasting and in sound-motion pictures. Talking motion-pictures owe their success and much of their apparatus to those investigations.

While these investigations were going on, there were simultaneously carried out in the development and design groups of Bell Laboratories other developments which have had their effect upon these fields. For public-address systems there were developments of high-power receivers which could reproduce for a large audience. As early, for example, as 1913, Western Electric equipment had been used for a successful loudspeaker demonstration between Oklahoma City and Tulsa. The Governor of Oklahoma, speaking over 122 miles of telephone line, addressed an audience in Tulsa.

By 1916 the development had reached a point where something of the future possibilities could be envisaged. At the

Newark (New Jersey) Velodrome there was set up a public-address system, supplying eighteen loudspeakers, which were capable of addressing twelve thousand persons. These loudspeakers were supplied with amplified currents from vacuum tubes. A much improved and larger installation was that along "Victory Way" in New York City in 1919. One hundred and thirteen loudspeakers, strung along Park Avenue from 46th to 49th Streets, were actuated by a single telephone transmitter. To this public-address system connections were also made from long-distance telephone circuits and from an electric phonograph for the reproduction of music from records.

A year later, in Chicago and San Francisco respectively, the national conventions of the Republicans and of the Democrats were held with the aid of public-address systems. In May, 1921, an installation was made by the Western Electric for the United States Chamber of Commerce Convention which was held on the million dollar pier in Atlantic City. There were connections as desired to long-distance telephone lines and to phonographs as well as to a newly developed microphone of the double-button carbon type. The condenser-type microphone had had its initial commercial appearance some time before.

Of all the public-address installations during those years perhaps the most impressive, and certainly the most elaborate, was that set up on Armistice Day, 1921, in connection with the broadcasting of ceremonies attendant upon the burial in Arlington Cemetery of The Unknown Soldier. Through public-address systems of Western Electric manufacture, on the designs of Bell Laboratories, and through the long-distance telephone, large crowds participated in those exercises, a hundred thousand at Arlington, thirty thousand in Madison Square Garden and in an over-flow meeting, and twenty thousand more in San Francisco.

This patriotic demonstration of 1921 was equally a demonstration that there had been introduced into the affairs of

men a new technological factor. No longer was the audience of an orator or musician definitely limited by the range of his own voice or that of his instrument. Wherever speech-bearing currents could be delivered, an installation of amplifiers and loudspeakers would reproduce for any size of audience. It made no difference whether these speech-bearing or music-bearing currents arrived at the amplifier over wires or by radio, or, as is the usual case today, by wire from studio to radio station and by radio for their dissemination throughout the immediately surrounding area. The telephone transmitter, improved by researches, had become the microphone for public address and broadcasting. The telephone receiver, similarly metamorphosed, had become the loudspeaker. And the vacuum tube, which had already extended the distance range of telephony and had demonstrated its function in radio telephony,* had become the amplifying element in the new one-way system of electrical communication. The tube itself, to perform its functions of radio detector and amplifier for a loudspeaking receiver, was destined to become the household companion of millions. It was even to surpass in its ubiquity the telephone transmitter itself. In any population, the portion of those who have messages to originate is less than of those who only receive.

The success of public address and broadcasting has been in large part the result of the research development of transmitters and receivers and of their intervening circuits whether these are geographically long as in wire telephony or short as in a radio receiving set. Enough of the component tones of speech and of music could be picked up and reproduced so that the ear of a listener could be pleased as well as informed. The factors underlying quality of reproduction in sound were gen-

* During 1915, Bell Telephone engineers, by transmission from Arlington, Va., to Paris, to Honolulu and to other points, had demonstrated the technical practicability of long-distance radio telephony and laid the foundation for radio broadcasting as well as for the transoceanic and ship-to-shore two-way radio telephony of today.

erally comprehended and further improvements were inevitable. Improvement, in fact, continued and reached its ultimate in April, 1933, in the telephonic transmission from Philadelphia and reproduction in Washington of a concert of the Philadelphia Orchestra. Every component tone of its rendition in Philadelphia, which a human ear in that auditorium could have perceived or appreciated, was reproduced in Washington for the ears of several thousand listeners. The high-quality, high-efficiency loudspeakers, and particularly the introduction of multi-cellular horns, set a new standard of performance. This new standard has been the basis for continued improvements in sound reproducing systems.

The development of a one-way telephone system for reaching immediately and simultaneously a large audience opened the way to other advances. Independent of any need for extending the distance over which a vocal message can be delivered—the social need which the invention of the telephone satisfied—there has always been some need for holding a sound for later delivery. This requirement the phonograph, or talking machine, undertook to satisfy. Through Edison and his successors, mechanical systems were developed for recording in wavy lines, on a disc or cylinder, the vibrations of a diaphragm exposed to sound waves, and for reproducing these vibrations from their records. Like the early telephone, the early machines for this purpose handled only a limited portion of the component tones of speech and reproduced them with the defects of distortion. Unlike the telephone, because the system was mechanical instead of electro-mechanical, the possible improvement in quality of reproduced sound was limited. It had reached its peak by about 1920; and shortly afterwards the phonograph industry was seriously threatened by the competition of radio broadcasting.

What the phonograph undertook to do was to record sound for subsequent reproduction. Into the transmission of sound,

between source and auditor, the phonograph inventor proposed to introduce an indefinite but controllable amount of delay. With its invention, speaking and listening lost their usual temporal relationship. Without its use, words passed through the air as waves of sound, demanding the attention of listeners at the moment of their arrival at their ears or else passing on to be lost forever to the inattentive. Through its use, the sound waves were effectively delayed, awaiting the interest and attention of listeners and resuming travel when that attention had been indicated by starting the phonograph. The sounds could be repeated over and over again merely by restarting the machine, and they were reproducible for anyone who possessed copies of the records and a machine. Just as a printed book carries the written words of its author impersonally to a variety of readers and at many different times, so the phonograph carries the spoken word.

The record was cut by a graver which was driven by a diaphragm which in turn was vibrated by the sound waves that were to be recorded. This mechanical vibrating system was selectively sensitive to pitch, recording well some component tones and making negligible record of others. In addition, it failed to respond to the fainter tones of music or speech. The result was distortion and impairment of the sound and "canned" music or speech, a thing unnatural—to which, however, phonograph users grew more or less accustomed and tolerant.

Phonographs from time to time have been of interest to telephone engineers. As far back as 1910 they were considered as sources of speech for practical tests of telephone transmitters. The phonographs of that day introduced too much distortion into their reproduction of speech, and the project was abandoned except for one of the cruder tests. Today, however, improved types of phonographs are used for many purposes in testing and in telephonic research work.

FURTHER BY-PRODUCTS OF TELEPHONE RESEARCH

Another project involving recorded speech was that of supplying telephonic currents corresponding to the spoken sound of numbers and letters so that dialing from a dial office might give rise to spoken words for the guidance of an operator in a manual office. Today that is accomplished by the "call announcer," a device in which currents from film records of speech are supplied to a circuit in accordance with dialed impulses. The first attempt along this direction had a trial in 1916, but the quality of the reproduced speech was too unsatisfactory.

While these attempts to utilize existing mechanisms were going on, the researches on electromagnetic devices, receivers, and transmitters were making rapid progress. As soon as these researches had produced high-quality transmitters and vacuum-tube amplifiers to associate with them, a revolutionary change in the phonograph art became practicable. A microphone could be set to pick up the sound, converting into waves of electricity in wires what a one-eared listener would have heard in its location. The current from the microphone could then be amplified and used electromagnetically to drive the graver. For reproduction, there was used another transmitter which was driven by a needle as it followed the wavy lines of the record. With this device, there were associated a vacuum-tube amplifier and a high-quality loudspeaker. By such electrical arrangements there were avoided the serious limitations which had previously been inherent in the recording and reproducing mechanisms of the phonograph.

The first public showing of this application of telephonic techniques to the phonograph art, and of the progress which had been made in producing electrically-cut records, was made in a lecture during October, 1922, by E. B. Craft, of the Western Electric Company. The lecture hall in New Haven, Conn., was equipped for the purpose with a high-quality amplifier and loudspeaker. This equipment reproduced speech from electrically-cut disc phonograph records. The records con-

tained a spoken discourse intended to accompany a showing of a silent motion picture called "The Audion."

The phonograph was played and its speech reproduced while the picture was being projected. Synchronism sufficient for the purpose was maintained by hand control. The result was a sound motion-picture—not the first, for Edison had done the same thing years before, but the first in which there was high-fidelity reproduction of the sound. Enthusiastic reception of this demonstration indicated some of the future possibilities for sound motion-pictures and encouraged development work along that line.

By the middle of 1924, the Bell Laboratories' development of equipment for electrically cutting phonograph records and for reproducing from them had reached a point where it was obvious that electrically-cut records were suitable for commercial use. The resulting process of recording was licensed early in 1925 to the Columbia Phonograph Company and to the Victor Talking Machine Company, both in this country, and to their associated companies in England. At that time there was some feeling by those concerned with phonograph sales that the public would be unwilling to buy electric reproducing equipment. A purely mechanical, or acoustic, phonograph was then developed and licensed to the Victor Talking Machine Company. This device, which was called the "orthophonic" phonograph, represented the result of the application to the problems of mechanical vibration of the electrical techniques which had been developed during the study of transmitters, receivers, and telephone lines.

Electrically-cut phonograph records had several advantages over the older style of mechanically-cut records. These advantages derived from the application of telephonic techniques, and from the utilization of the latest developments in telephone equipment. When sound is picked up by a mechanical system, as for example a diaphragm which drives a graver, the power

output of the system in cutting wax grooves cannot be greater than the power input of the sound waves. The diaphragm serves to transmit to the graver the air pressure of the sound wave, but not all the power of the wave is delivered because some is lost in overcoming the frictional resistance of the diaphragm.

When, on the other hand, sound is picked up by a carbon-button telephone transmitter, there is an actual amplification of power. The diaphragm in its vibration varies the area of contact of the carbon grains within the button and so varies the electrical resistance of that button. Current flows through the button from a battery, and the amount of current varies with the vibration of the diaphragm. The output of the transmitter in the form of electrical power is not limited to the power input of the sound waves. The mass of carbon grains in the button, which shrinks and expands alternately during the vibration, acts as a valve to control the power output of the battery. What a telephone transmitter accomplishes, therefore, is not merely the translation of air vibrations into electrical, but the production of more powerful electrical, vibrations corresponding to those in air.

Before the application of telephonic methods to the phonograph art, when the wax record was cut by the power of the sound waves, faint tones were lost in recording because they could not drive the graver. A horn was used to direct the sound to the diaphragm, and the artists had to be grouped closely in front of the horn's opening so that their speech and music could exert the greatest possible force on the recording mechanism. An orchestra while recording was arranged in an awkward and unusual manner, and even the instruments were altered. The violins had horn or pipe attachments so as to give greater amount of sound but, of course, not the usual tone quality of a violin. Using a telephone transmitter, all this became unnecessary; the orchestra took its usual seating and

played its regular instruments, while a microphone in front of it picked up the music.

Picking up through a microphone and amplification of its current by vacuum tubes assured greater power for driving the graver. Improvements in transmitters and in loudspeakers, and telephonic developments of an electromagnetic mechanism for driving the graver, completed the revolution of the phonograph art.

While this phonograph development was going on in the Bell Laboratories, there was also progressing a related development. In one of the groups engaged in acoustic investigations, there was developed a photographic method of recording. Speech-bearing currents were caused to operate electrically a shutter or light valve. This controlled the amount of light falling on a moving film and so recorded on the film in variations of photographic density the variations in the current. For reproduction, the film was run between a lamp and a photoelectric cell. The cell originated a current proportional to the amount of light which fell upon it and hence, in turn, proportional to the current which was responsible for the variations in light and shade of the film.

This is the "variable density" method of recording sound on film, which has found world-wide use in Western Electric systems for sound motion-pictures. Some years before it became effective in the motion-picture world, one of its essential elements, the light-valve, and its companion, the photoelectric cell, had been adapted to the telephonic problem of the electrical transmission of pictures. These elements were used in the telephoto system which was put into commercial service in 1925, and are used in the present-day system.

The idea of sound motion-pictures was old, but it did not reach fruition until the telephonic developments in sound recording prepared the way. For sound motion-pictures to be successful, there are three requirements: first, that the picture

itself shall satisfactorily reproduce the scene; second, that the accompanying sound shall in quality of reproduction have sufficient verisimilitude and naturalness; and, third, that the reproduced sound shall be synchronized with the picture. Advances in photography met the first requirement, but it was because of inability to meet the second that early attempts were abortive. The third requirement could not become controlling until the second had been met. It was, however, relatively easy to meet and did not appreciably delay the success of sound pictures.

By 1924 there had been developed telephonic equipment and methods through the use of which there could be met the second requirement for sound pictures. Speech and music could be picked up, recorded, and reproduced for a large audience and with the necessary high quality and faithfulness. For recording, there were available both the method of electrically-cutting disc phonograph records and that of photographically recording the sound as a track on the picture film. The phonograph method was adapted by developing the proper equipment for synchronization. It was then licensed to Warner Brothers, and in 1926 had its premier performance under the trade name of "Vitaphone."

By the summer of 1928, most of the large producers of motion pictures in the United States had been licensed to use Western Electric systems. Of the two available methods, they preferred the photographic. In their studio work, however, they found great convenience in recording simultaneously by both methods, because the wax record could be played back immediately so that "retakes" could be made before the actors were dismissed from the set. For theatre use it was a convenience, on the other hand, to have both sound and scene on the same film. One advantage was the ease of patching when film breaks occurred and some frames of pictures and inches of sound track were lost in the operation of patching. For

theatre use, film recording became preferable and was soon adopted by Warner Brothers also.

The equipment which the Laboratories had originally designed and the Western Electric had manufactured was no crude model: it was a full-fledged system which permitted the production and projection of widely popular sound pictures. The original design, by comparison with the automobile, would stand alongside those models which just preceded stream lining rather than with the horseless carriages of the early years. Science and engineering, however, are dynamic and vital; nothing which they create can satisfy indefinitely; progress is inevitable. No sooner, therefore, had the Laboratories proved its design through its commercial acceptance than new features of design took form in the inventive minds of those engineers most concerned; new applications of ideas just derived from fundamental telephonic researches pressed for apparatus embodiment in improved sound-picture equipment. The necessary development work was therefore undertaken and from it have come many important advances, chief of which in popular appeal are the "noiseless recording" that was introduced to the theatres some years ago, and the "wide range recording" which increased the exactness of sound reproduction.

Although much progress has been made since 1928, when the sound picture became universal, the fundamentals upon which the art stands are the telephonic researches of the preceding half century, and particularly of the years 1912 to 1924. It was those years which produced also the public-address system, improved methods of recording, and basic techniques and equipment for radio broadcasting.

JOHN MILLS

Behind the Scenes in a Central Office

TO the every-day telephone user, the telephone central office is a vague entity in the background of the service where, in some mysterious fashion, connections are established, in response to his orders, with whomsoever it may be his desire to reach.

This central office is the heart of the telephone network, and upon its proper functioning depends to a vital degree the quality of the telephone service and the subscriber's impression of it. The central office is the doorway to the telephone world. Every subscriber's line centers there, and through it each subscriber is given access to each of the hundreds or thousands of other subscribers in his own community and to those in neighboring communities, anywhere in the state or nation and, indeed, to nearly every telephone throughout the nations of the world. There is a local central office for almost every community: over six thousand of them in the Bell System. Through interconnecting lines and trunks and through the medium of long distance switchboards, they are linked into one common system to provide a unified telephone service for the country as a whole.

To many, the central office is a switchboard where operators sit before a bank of blinking lights, reaching for them with plugs on the ends of long cords and saying "Number, please,—Thank you," "Number, please,—Thank you," all day long. Close examination of that switchboard will reveal that it is made up of many small operating parts, such as keys, lamps, jacks, plugs, and cords which, all told, quickly count up to hundreds even on a small switchboard in a country town. And in the inside of the switchboard and in the apparatus or terminal rooms are other hundreds of small operating parts which are

necessary to make the lamps light, to ring the bells, and to perform the countless other mechanical and electrical operations essential to the rendering of telephone service. In the bigger towns and cities, the switchboards are much larger, including cities where the dial system is used to complete local calls, and the number of individual operating mechanisms required to perform the central office functions mount up to hundreds of thousands in each office. In dial offices the equipment is most complex, a much greater variety as well as quantity of mechanisms being needed to perform the intricate switching operations involved in setting up calls mechanically.

Large as may be the quantity and variety of electrical and mechanical units of which the central office is composed, they must all work together with the reliability and precision of a single well-oiled machine. Even the most simple form of telephone connection calls into play the joint operation of at least a dozen different mechanical elements of the central office equipment, either at the switchboard or in the associated equipment. The more complex dial connection may employ several hundreds of these unit mechanisms on a single call. The great majority of the equipment units are used over and over again by different calls, sometimes for only a few operations a day, commonly for several hundred operations a day, and in some cases tens of thousands of times a day.

To meet the demands of this exacting service, the equipment is, of necessity, ruggedly designed and built to perform its functions with a minimum of attention. It is to be expected, however, that in time there will be a certain amount of deterioration due to wear, fatigue, dirt, corrosion, etc., which must be compensated for by adjustment, repair, and cleaning operations to ensure continued good telephone service to every subscriber. This, in general, is the function of the central office maintenance forces, comprising many thousands of plant men in the Bell System, and the methods which they employ and the tools which they use are largely the product of activities of

hundreds of other men distributed through the several supervisory and engineering staff groups in the telephone organization.

Maintenance activities, in general, may be roughly grouped in two categories, the one preventive and the other corrective. In telephone practice, prevention of operating irregularities is the paramount objective, and preventive maintenance, therefore, occupies the major position in the maintenance program; but corrective maintenance is also a necessary part of the maintenance man's duties. In addition, the maintenance forces have certain other operating functions, such as connecting, disconnecting, and rearranging the wiring whereby subscribers' lines are connected to the central office equipment, and the routine operation of the power plant, which is part of the central office equipment. For the sake of simplicity, we shall confine our attention to the functions which are more directly concerned with keeping the equipment in good working order.

PREVENTIVE MAINTENANCE

One of the principal processes of preventive maintenance is so-called routine tests or inspections, and these play a large part in the work assignments of the central office maintenance man. The "routines" are regularly scheduled physical examinations or electrical tests of particular parts of the equipment, designed to disclose faulty conditions that may require correction. A routine inspection, for example, may involve a measurement, with suitable gauges, of the physical condition of switchboard plugs, intended to show what plugs, if any, may have become worn or damaged to the extent that they are on the verge of causing "cut-outs." Such an inspection would be scheduled often enough to eliminate practically all the potentially defective plugs before they cause service reaction. Similarly, inspections are made on other apparatus to determine the condition of wear or adjustment and the general state of

repair or cleanliness. Special tools or gauges are employed to facilitate these operations.

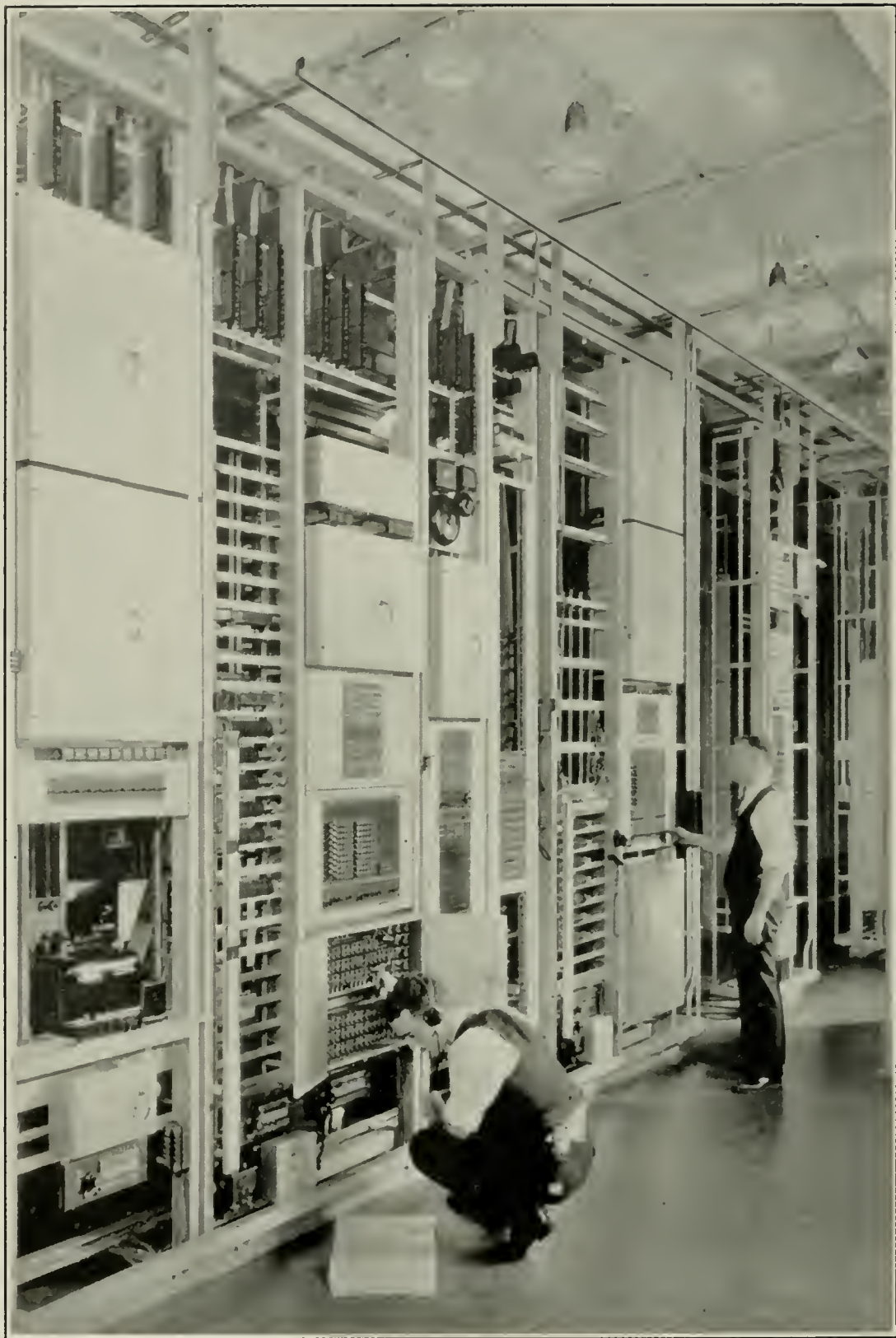
Because routine inspections might at times have a tendency to disturb working equipment through unnecessary handling of parts which are in good working order, they have, in recent years, been restricted to those few items of equipment where the inspection method was particularly appropriate, and greater emphasis has been placed on routine tests. These are, for the most part, electrical tests of the operating functions of the equipment, performed more or less in a manner corresponding to the way the equipment is used in service, and are, therefore, not disturbing to the equipment.

A typical routine test, for example, would be an operation test of a switchboard cord circuit: i.e., of the combination of cords, plugs, keys, lamps, relays, etc., which functions as a unit to provide the means whereby an operator may connect one line with another at the switchboard. The test would consist of connecting the cord circuit to certain testing equipment and of manipulating various keys in such a manner as to bring into play the operating features of the cord circuit. Thus the cord circuit would be tested for the ability to give the proper lamp signal when connected to the line of a calling party, together with the proper signals when that party disconnects or wishes to recall the operator; it would be tested for the ability to ring on a called line and to receive the proper signal when the called party answers or disconnects; and it would be tested for other operating features such as the collection or return of coins at a coin telephone.

In making these tests, the testing equipment is arranged to simulate as far as possible the most rigid operating requirements for each of the features, so that irregular conditions will be indicated before they affect service. Such routine tests provide a means of periodically checking the equipment for operating capability and show where potential trouble may exist. Each fault is corrected as found; but if the tendency is for



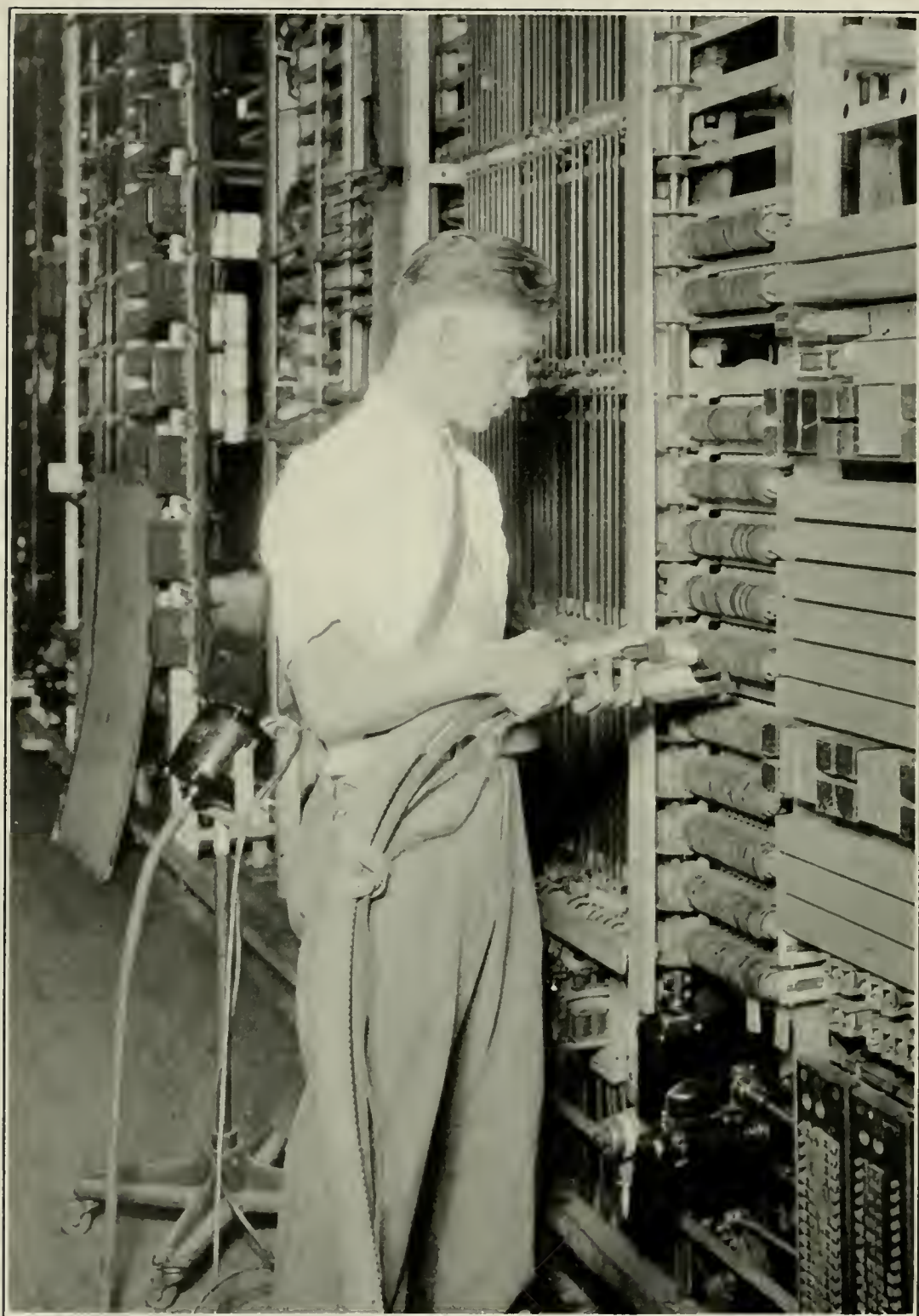
ROUTINE TESTING IN A STEP-BY-STEP DIAL OFFICE.



TRACING TROUBLE ON A CIRCUIT, AND OPERATING A TEST FRAME, IN A PANEL-TYPE DIAL OFFICE.



ADJUSTING RELAYS IN A STEP-BY-STEP DIAL OFFICE.



COMBINED MECHANICAL AND VACUUM CLEANING OF SEQUENCE SWITCHES IN A
PANEL-TYPE DIAL OFFICE.

more defects of a particular kind to appear than past experience has shown to be normal, extra measures, such as special inspections or reconditioning operations, are then undertaken, to discover the cause for any such unfavorable trend and apply the proper correction. The routines thus serve either as a direct means of eliminating the faulty conditions or as a measure of equipment conditions by which the need for other maintenance treatment is indicated.

Still one other group of "routines" should be mentioned as having a major place in the maintenance man's trouble preventive program: namely, certain periodically recurring work operations which are concerned with preserving desirable physical conditions in the equipment or its environment. In this category, the chief items are lubrication and cleaning. Lubrication is necessary in many of the mechanisms to prevent wear or corrosion. Manual office equipment does not require lubrication to any great extent, but in dial offices the various switching mechanisms have many small bearings or impact points which must be kept lubricated. Since these points of lubrication may number in the tens of thousands in a single office, it can be seen that lubrication on the average of even once a year is a sizable work assignment.

The routine cleaning operations collectively constitute an even greater task and, of course, apply to all types of offices. The cleaning work ranges from simple dusting operations with cloth or vacuum cleaner on the exposed surfaces of the equipment to more specialized abrasive polishing and treating of contact surfaces, such as, for example, the periodic polishing of switchboard plugs to remove tarnish. The cleaning efforts are important from the preventive maintenance viewpoint because the essential function of all the relays and other switching devices comprising the equipment of the telephone office is the opening and closing of hundreds of thousands of small contacts that complete the electrical circuits hundreds or thousands of times a day. Modern telephone design has produced contacts

that are virtually perfect in performance, when the millions upon millions of operations expected of them in their useful service life are taken into account. But considering the large number of contact closures required for even a single call, the maintenance objective is to prevent even the random contact failures which may occur as infrequently as once in several hundred thousand contact closures. All the cleaning operations contribute to this objective by preventing the accumulation of dirt or products of corrosion that might interfere with the proper operation of the equipment.

The various routine tests, inspections, and other work operations are administered according to a definite schedule which has been worked out by experience to provide a systematic coverage of most of the operating equipment within some definite time interval. This interval varies for different parts of the equipment according to their nature, the rate of use to which they are subjected in service, the past experience as to their susceptibility to trouble, etc. Thus certain routines may be performed only once a year, while others may be done quarterly, monthly, weekly, or even once a day in some few cases. This program serves to detect the great majority of irregularities that are likely to affect service but, without going to excessively costly extremes, there will still be some irregularities which will show up in operation. This leads us to a consideration of the corrective type of maintenance activity, which originates in the work of trouble tracing as the result of circuit alarms or reports from external sources.

CORRECTIVE MAINTENANCE

The circuit alarms are signal arrangements incorporated in the equipment to provide automatic indication of certain kinds of operating irregularities or failures. When a fuse operates, for example, as the result, perhaps, of a short circuit in some part of the wiring, one or more lamps light and a bell is sounded in the terminal room where the equipment is located. The

lamps indicate the kind of failure that has occurred and guide the maintenance man to the part of the equipment which is affected. There are various alarms of this general type, which call attention not only to blown fuses but also to certain irregular conditions, such as the failure of one of the automatic selectors in a dial office to release properly at the end of a call. These alarm arrangements maintain automatic supervision over many of the central office equipment functions. They operate, of course, only when some sort of irregularity has occurred, but because they are virtually instantaneous in their indication, they are an important adjunct to the preventive maintenance program and afford a continuous safeguard to service. They can be utilized by the maintenance forces as a means of disclosing certain kinds of potential trouble conditions, and in that respect function somewhat like routine tests to indicate when certain special preventive or corrective maintenance work may be required.

Such relatively few troubles affecting service as do occur through conditions not disclosed by preventive maintenance, or those occurring between routine tests, are usually brought to the attention of the maintenance forces by operators' or subscribers' reports. An operator, because of her continual use of the circuits, is in a position to detect certain types of irregularities quite promptly during their occurrence, or at least more quickly than they would be disclosed by routine tests. When she does notice such equipment irregularities, she brings them to the attention of the maintenance forces either orally or by means of a "trouble ticket," in accordance with the reporting routine followed in that particular office. The maintenance man investigates these reports by making appropriate tests or inspections of the equipment involved, and locates and corrects whatever faulty conditions may be present. Similarly, the subscribers in their use of the service experience occasional difficulty on a call and make reports to the operators or to the repair bureau, which are relayed to the central office mainte-

nance forces if central office trouble is indicated as a possible cause of the difficulty. The maintenance man is required to analyze such trouble reports to determine what part of the equipment might be responsible for the fault, after which he makes the necessary tests and inspections to localize possible irregular equipment conditions.

TOOLS AND TESTING EQUIPMENT

For the performance of the numerous and varied operations that are expected of him, the maintenance man is provided with many special types of tools and testing devices, each especially designed for its particular purpose. The use of gauges and test sets in the performance of routine and trouble-clearing tests and inspections has been indicated. In addition, the repair and adjustment work may require other special tools and testing devices.

The tools may be simple devices such as wrenches or screw drivers, sometimes with slightly special shapes to facilitate access to and ready manipulation of adjusting nuts and screws in the performance of some of the more frequent types of adjustment work; or they may be quite elaborate kits of tools such as might be required for commonly recurring repair operations, of which switchboard cord repairs, involving the cutting back of frayed cord ends, "serving" the cords, "tipping" the conductors, and replacing the plugs, might be cited as a typical example. The gauges used in inspection and adjustment work are special measuring devices by which the essential dimensions of the apparatus, as, for example, spring tension, armature travels, contact point clearance, etc., may be checked, to detect either wear or the condition of adjustment. They, too, may be very simple or quite complex. The testing equipment may be small portable devices such as meters or testing circuits assembled in carrying cases, or it may take the form of permanently mounted equipment arranged to be controlled



CLEANING AND ADJUSTING SWITCHBOARD KEYS.



REPAIRING SWITCHBOARD CORDS.

from a distance or to perform tests automatically, as in the case of some of the testing equipment used in dial offices.

All of these tools, gauges, and testing devices are designed with a view to providing the most convenient, efficient, and accurate arrangements possible in consideration of the highly repetitive nature of most of the work operations in which they must be used. They incorporate the necessary features whereby the mechanical or electrical condition of the equipment may be checked and assured to be proper for the various service conditions in which it may be employed.

METHODS AND TECHNICAL INFORMATION

It will be apparent that the knowledge which is required of the central office maintenance man is of a highly specialized character. Even with a broad basic knowledge of his duties, the specific details are so numerous and varied and the developments in the art are so rapid that he must be provided with considerable technical reference and instruction material to equip him fully for the day-by-day conduct of his job. This is provided in the form of blue-print drawings and circuit description pamphlets and more particularly in a series of standard practice instructions called "Bell System Practices."

The drawings give equipment and wiring information and some adjusting information and the "circuit descriptions" tell how the equipment works. The Practices cover the methods of doing the specific maintenance work operations and give various kinds of data that are needed in the course of the work. Thus there will be a section of Practices covering each routine test, for example, telling what testing equipment to use, how to set it up and connect it for the test, how to operate it to make the particular kinds of tests to which the equipment should be subjected, and what the indications of satisfactory or improper operation may be. There will be a section describing each adjustment procedure and the more complicated types of repair operations. The adjustment sections, together with the

BELL TELEPHONE QUARTERLY

adjusting information on the circuit drawings, will give the various dimensional or electrical testing limits by which the apparatus may be checked for operating capability and, usually,

BELL SYSTEM PRACTICES
Central Office Maintenance
Tests and Inspections

SECTION A252.002
Issue 3, 1-18-34
Standard

SELECTOR OPERATION TEST

USING TEST SET SD-90210-01 OR SD-90416-01

350 AND 360 COMMUNITY DIAL OFFICES

1. GENERAL

1.01 This section describes a method of testing the pulsing, cut-in, holding, releasing and switching-through functions of local selectors.

1.02 This section has been reissued to provide for the use of test set SD-90416-01.

1.03 Different levels should be used each time this test is performed, so that eventually every selector will have been tested for cutting in on each level.

1.04 When testing an incoming selector, the trunks should be made busy in the approved manner during the test.

1.05 If a failure is encountered on any selector, it should be held busy in the approved manner until the trouble is cleared.

2. APPARATUS

2.01 Test Set SD-90210-01 (J34704A) or SD-90416-01 (J94704A).

2.02 One P3C Cord equipped at one end with a No. 110 Plug and at the other end with a No. 240-A Plug.

2.03 One P3E Cord equipped with No. 110 Plugs.

3. PREPARATION

3.01 Locate the test set at the selector frame.

3.02 Connect the BAT-G jack of the test set to the 48-volt battery supply jack located on the selector frame using the P3E cord.

3.03 Insert the No. 110 plug of the P3C cord into the T jack of the test set.

3.04 When using test set SD-90210-01 operate the SD key and leave it in the operated position during the tests.

3.05 Insert the No. 240-A plug of the P3C cord into the test jack of the selector to be tested. If the switch is busy the BSY lamp on the test set will light, in which case the plug may either be removed in order to proceed with other tests, or left in the test jack and the test delayed until the BSY lamp is extinguished.

4. METHOD

4.01 Operate the LP key and note that the BSY lamp on the test set lights.

4.02 When testing selectors arranged to absorb the initial digit on all levels or selectors arranged to absorb the initial digit on individual levels as required, an extra digit must be dialed before proceeding with the operation test as outlined in 4.04, on levels arranged in this manner.

4.03 When testing selectors arranged to absorb digits repeatedly on one or more levels, dial the digit for the particular level arranged in this manner several times and note that the switch releases after each series of pulses.

4.04 Dial the designated level and note that the switch steps smoothly to the proper level and rotates to an idle contact. The REV lamp on the test set should not light. In event the REV lamp lights, the indication is that the tip and ring wiring of the selector is reversed.

Note: In offices where vacant level trunks are made busy, the switch should rotate to the 11th rotary position when a vacant level is dialed.

4.05 Release the switch by restoring the LP key. Note that the BSY lamp on the test set is extinguished when the switch releases.

4.06 Operate the LK key and repeat the operations described in 4.04 and 4.05 with the LK key operated instead of the LP key.

5. REPORTS

5.01 The required record of these tests should be entered on the proper form.

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Page 1
1 Page

A SECTION FROM BELL SYSTEM MAINTENANCE PRACTICES, DESCRIBING
A ROUTINE TEST.

a closer set of limits to which it should be readjusted so as to ensure some added margin of safety against deterioration of the adjustment with time. The repair sections will give constructional details and information for identifying repair parts in ordering from the supplier, together with detailed instructions on dismantling and assembling the apparatus and methods of effecting repairs where old parts are reused. There will also be sections covering the technical details of most of the commonly recurring work operations such as the methods of tracing circuit alarms, the methods of handling trouble reports, the methods of operating the power equipment, etc., and various descriptive sections of an informative or educational character on matters related to the maintenance function.

These Practices, being issued in sectional form averaging five or six pages each, are readily kept up to date by reissues, so that the maintenance forces may be quickly informed of the development of new or improved methods of doing maintenance work, or of the use of new tools, testing devices, materials, etc., as they become available.

The present day methods of maintenance and the tools, testing devices and other facilities which contribute to their efficiency are the result of many years of experience and development effort. These methods today are the best that human ingenuity has been able to devise, but suggestions from the field maintenance forces growing out of their day-by-day operating experience, and the findings of study and research on the part of the staff groups of the A. T. & T. Company and the Bell Telephone Laboratories, are continually pointing the way to new methods of doing the work and to better facilities for the task. The objective of the telephone maintenance man is improvement, a constant striving toward the goal of perfection that is so characteristic of the great telephone family of which he is such a necessary and vital part.

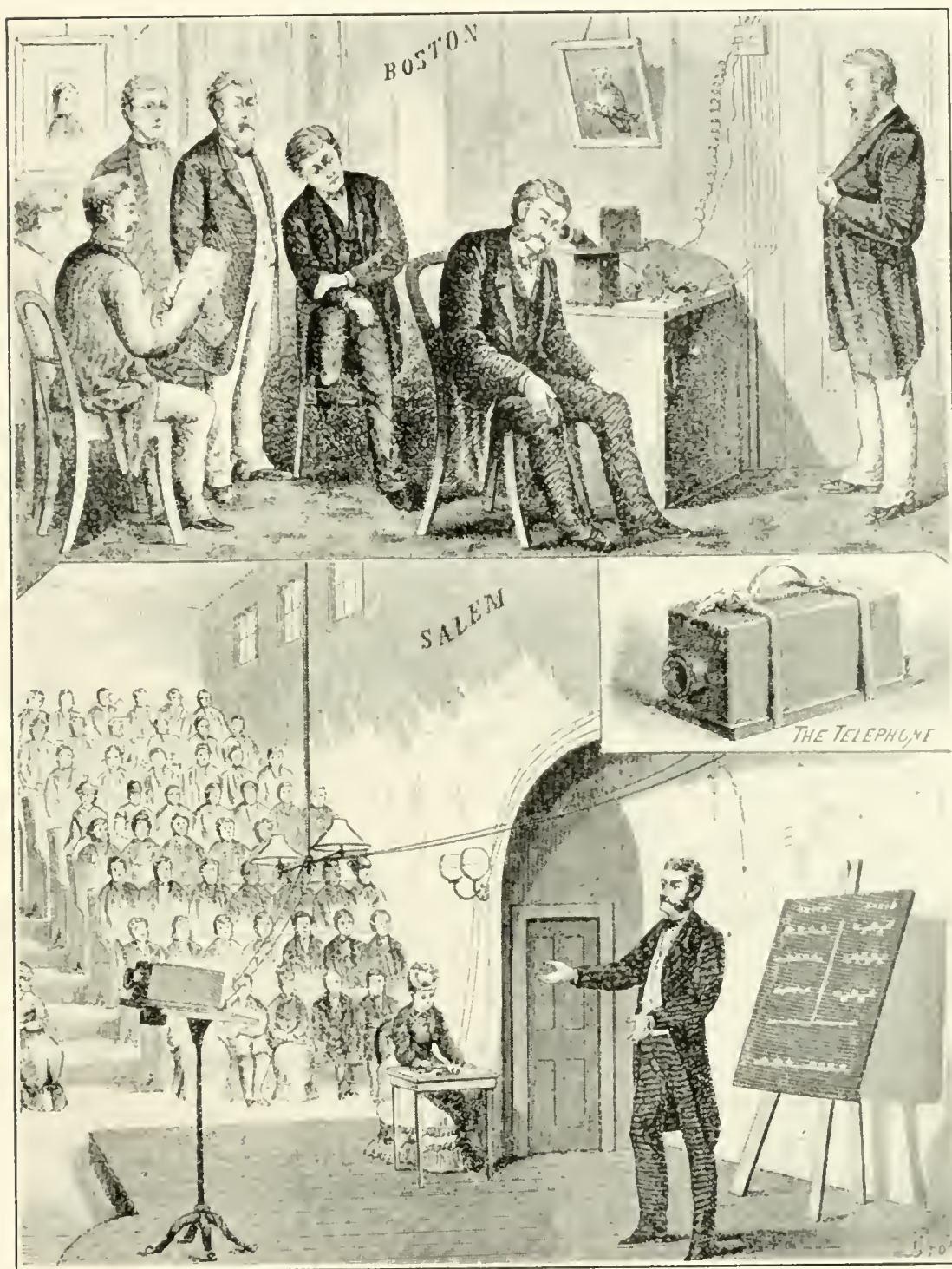
P. C. SCHWANTES, JR.

Some Early Telephone Prophecies

WHEN the telephone was first introduced, it was regarded with apathy or skepticism by the general public, and there were probably very few people, outside of its inventor, Alexander Graham Bell, and his immediate associates, who had any confidence in its future. Even for some years after the inauguration of a commercial telephone business, the full nature of its possibilities was not generally recognized. With this situation in mind, therefore, it is interesting to discover that there were, even in those early days, at least a few people gifted with prophetic vision or vivid imagination, and it is the purpose of this article to bring together, within the space of a few pages, a number of prophecies—serious and otherwise—regarding the future possibilities of the telephone, that appeared in print during the first few years after the invention of that important instrument.

In this list of examples of prophetic vision, first place will be awarded to Alexander Graham Bell's prospectus, written at Kensington, England, on March 25, 1878, for the purpose of promoting the use of the telephone in that country. This document was written at a time when the telephone art and business were as yet undeveloped, when there were no telephone cables and no commercially practical transmitter, and when the first telephone exchange had been in operation less than two months. The following paragraph from this prospectus will be familiar to most readers, since it has been reprinted many times:

It is conceivable that cables of telephone wires could be laid underground, or suspended overhead, communicating by branch wires with private dwellings, country houses, shops, manufactories, etc., etc., uniting them through the main cable with a central office where the wires could be connected as desired, establishing direct communication between any



THIS WOOD CUT, REPRODUCED FROM THE SCIENTIFIC AMERICAN OF MARCH 31, 1877, SHOWS ALEXANDER GRAHAM BELL LECTURING TO AN AUDIENCE AT SALEM, MASS. THE INVENTOR IS ILLUSTRATING HIS DEMONSTRATION BY MEANS OF A TELEPHONE PLACED BEFORE HIS AUDIENCE AND COMMUNICATING WITH HIS LABORATORY AT BOSTON, FOURTEEN MILES AWAY.

SOME EARLY TELEPHONE PROPHECIES

two places in the city. Such a plan as this, though impracticable at the present moment, will, I firmly believe, be the outcome of the introduction of the telephone to the public. Not only so, but I believe, in the future, wires will unite the head offices of the Telephone Company in different cities, and a man in one part of the country may communicate by word of mouth with another in a distant place.

Another striking example of prophetic vision is the certificate of incorporation of the American Telephone and Telegraph Company, filed on March 3, 1885. The following paragraph from this certificate has also been quoted on many occasions:

And it is further declared and certified that the general route of the lines of this association, in addition to those hereinbefore described or designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said state, and in each and every other of the United States, and in Canada and Mexico; and each and every other of said cities, towns and places is to be connected with each and every other city, town or place in said states and countries, and also by cable and other appropriate means with the rest of the known world, as may hereafter become necessary or desirable in conducting the business of this association.

The above words were written at a time when intercommunication by telephone was limited to about 250 miles, 30 years prior to the completion of the first transcontinental line, and over 40 years prior to the inauguration of transoceanic telephone service.

Another prophetic statement is contained in the first annual report of the Mechanical Department of the American Bell Telephone Company, signed by E. T. Gilliland, Superintendent, and dated February 18, 1885:

That this Department will become more useful to the Company as time goes on cannot be doubted. New and unexpected channels of usefulness will appear and the general aim of all our work should be not merely the improvement of the service in special directions but the establishment of uniformity in methods employed by different exchanges looking to the adoption of one universal telephone system.

This is thought to be one of the earliest references, if not the earliest, to the necessity for uniformity in methods throughout the Bell System. At the time when these lines were written, there were twelve employees in the Mechanical Department, including Mr. Gilliland, and less than twenty-five in the entire technical staff of the American Bell Company. There were 135,000 telephones in the Bell System and 137,000 miles of wire.

Reference will next be made to a number of news articles that appeared in the public press at a somewhat earlier period—in fact, very shortly after the invention of the telephone. Readers familiar with the sequence of events preceding the inauguration of a commercial telephone business, in May, 1877, will remember that Bell's telephone was patented in March, 1876, and first brought to the notice of the general public by his paper "Researches in Telephony," read before the American Academy of Arts and Sciences on May 10, 1876, and by its exhibition at the Centennial Exposition in Philadelphia in the following month. Bell spent the next few months in improving his telephone and in trying out its capabilities on existing telegraph lines. He also delivered a series of lectures, in various cities, during the winter and spring of the year 1877, designed to popularize the use of the telephone. These experiments and lectures—the latter being accompanied by demonstrations of the transmission of speech and music between places separated by a moderate distance—were given wide publicity in the newspapers of the United States, and in view of the fact that the only telephonic apparatus or equipment in existence at the time was Bell's crude box telephone, operating without a battery, some of the prophecies contained in the following press notices are quite astonishing:

Springfield Republican, February 15, 1877

Prof. Bell, the accomplished teacher of "Visible Speech," has been experimenting, for a year or two, on a method of making speech audible,

SOME EARLY TELEPHONE PROPHECIES

through the telegraph, at a distance of many miles, and has had, of late, much success in this. On Monday night, he placed one of his instruments in Salem, and another in Boston, and was able to transmit words and tones back and forth, and even to send applause by telegraph. The instrument used is termed by him the "telephone,"—transmission being by sound, and not by writing, as in the common method. Important practical results may come from this invention, which Prof. Bell and his associate, Mr. Watson, are perfecting for general use. But some of the possibilities of it are rather startling. A stump-speaker, by this method, could perhaps be heard, on the same day, in all the cities and villages of the United States, so that a half-dozen campaign speakers would be enough for the new presidential election. . . . Again, by an instrument skillfully arranged, all the music of a prima donna could be distributed over the country while she was singing, thus popularizing good music to an extent as yet unknown. The Metropolitan newspapers could employ persons to read their articles to subscribers in distant parts, so that the expense of printing and mailing copies would be no longer necessary. By a judicious distribution of instruments, a whole parish might hear its minister preach on a stormy Sunday, without his leaving his study. . . . Wonderful are the achievements of science, by which the filing of a saw, or the flute-playing of an amateur, may be heard round the world like the morning drumbeat of the British army, or the shot fired at Concord Bridge.

It is interesting to note that the prophecies that a speaker might some day be heard in all the cities of the United States, and that the music of a prima donna could be distributed over the country, have been realized, in recent years, by means of instrumentalities unknown and undreamt of at the time when this article was written.

New York Sun, February 20, 1877

The following remarks were extracted from an article recounting an interview of a *Sun* reporter with Thomas A. Watson, Alexander Graham Bell's assistant:

"I haven't the slightest doubt," Mr. Watson said today, "that in a few months things will be so that a man may make a lecture here in Boston and be heard by an audience in any part of the country. . . . A company is now forming for the purpose of manufacturing and introducing the

instrument. . . . We expect, at first, it will be used mostly on private lines and for city business. . . .”

Apropos to singing by telegraph, I asked if it would not save a good deal of expense to our American opera managers. “An American audience could hear Nilsson, Patti, or any European prima donna, without bringing them across the Atlantic,” I suggested. “Just place the receiving machine in the Boston Music Hall, for instance, and let the songstress put her mouth close to the mouthpiece in Paris, London, Vienna or St. Petersburg, and the effect would be the same as if the prima donna herself were present in the flesh.”

“Certainly,” said Mr. Watson, smiling, “and it would be curious to observe what effect the presence of the voice and absence of the person would have on the critics. Homely singers would probably advance in public esteem, while some of the beautiful cantatrices might suffer a corresponding set-back when their voices were judged on their merits.”

No trial has been made, however, of the transmission of sounds to so great a distance as across the Atlantic. Mr. Watson said that as far as they had been able to ascertain, there seemed to be a limit to the distance over which the sounds could be made to travel; but he expressed himself as confident that in due time any given distance could be annihilated.

Boston Herald, February 24, 1877

The following extract is from a news account of Professor Bell's lecture and demonstration at Lyceum Hall, Salem, Mass.:

The lecturer then proceeded to mention some of the advantages which would be gained in the event of the general adoption of the telephone, by transmitting messages, such as making business arrangements, calling the doctor, and ordering a dinner and the like, without leaving home.

Providence Daily Journal, March 15, 1877

It is not improbable that methods will be found of reinforcing the sound transmitted so that the voice at the end of the journey may be louder than the original spoken words. The principle of the relay may also be applied to the telephone, so that the words whispered into the telephone ear at Boston may be repeated at the same instant in a hundred cities! When some future President is inaugurated, may not his words be caught by a telephonic ear, and be repeated to listening audiences all over the land?

SOME EARLY TELEPHONE PROPHECIES

Although intensive work was carried on, almost from the invention of the telephone, in the attempt to devise telephone relays or repeaters, several decades had elapsed before a commercially practical amplifying device was developed.

Lowell, Mass., Citizen, April 26, 1877 (Editorial)

Professor Bell believes that in the near future a central telephone office will be established in all our cities, with which the police, the fire department, most business houses and many private residences will have connections. When this is done any person having the connection can call the police, report a fire, order a dinner or chat with a neighbor without leaving the room.

This is believed to be the first editorial reference to a telephone central office. It does not, however, mark the inception of the idea in Bell's mind, as is shown by the following extracts from a letter which he wrote at a later date:

The idea of an Exchange Telephone system was one of the earliest conceptions, in connection with the possible use to which the telephone could be put. I discussed it with my associates, Mr. Hubbard and Mr. Sanders, long before the date of the Centennial Exposition in 1876. . . .

While therefore the idea was original with myself the execution of it has been due to others. I have no doubt that others also may have independently reached the conception, for . . . telegraphic exchanges of various kinds were already in existence at the time the telephone was first made known to the public. . . .

I do not know of my own knowledge to whom we are indebted for the first telephone exchange, but this I do know, that my conception of it antedates that of all others, because it goes back to the very inception of the telephone itself before it was made known to others.

For the sake of the record, it may be stated here that the first commercial telephone exchange was opened for service in New Haven, Conn., on January 28, 1878, by George W. Coy.

Springfield Republican, May 14, 1877

We have grown so used to new and marvelous additions to the power of telegraphy that nothing seems impossible, and Prof. Bell's confident

expectation that he will shortly be able to send his voice across the Atlantic and talk with men 3,000 miles away as readily as if they were in the next room, meets with no such incredulous and satiric hearing as Cyrus W. Field's first proposal to lay an ocean cable 20 years ago. Our discoveries in managing the powers of nature are indeed so rapid and continuous that miracles have fairly become commonplace. . . .

The practical uses of the invention are suggesting themselves already. Whether the transmission of music will ever be more than a matter of curiosity it is not necessary to consider. But that the conversational capacities of the telephone are, even in its present imperfect condition, equal to genuine usefulness, seems obvious. Among the purposes to which it will be applied first are for conveying intelligence in mines, which is already under consideration; communicating from one office with a large number of factories, for which a prominent New England manufacturer intends to utilize it as soon as may be; and for the benefit of divers beneath the ocean.

It does not seem likely that Professor Bell had, at that time, any immediate expectation of talking over the Atlantic cable. Whether he did or not, it was soon discovered that telegraph cables, whether on land or under water, were entirely unsuited to the transmission of speech. It is only in recent years that the telephone art has advanced to the point where it is possible to talk a distance of 3,000 miles over a specially designed telephone cable, equipped with amplifying devices.

With regard to the statement that "our discoveries in managing the powers of nature are indeed so rapid and continuous that miracles have fairly become commonplace," it may be noted that at the time those words were written there was no electric light, no electric railway, no phonograph, no motion picture, no automobile, no X-ray, no skyscraper, no radio and no airplane.

New York Times, May 20, 1877

The last of these newspaper quotations is from an account of Professor Bell's lecture in Chickering Hall, New York City:

Then the Professor went on with his explanation. He intimated that the telephone might be put to a "flood" of uses, only a few of which time

SOME EARLY TELEPHONE PROPHECIES

would allow him to name. A business man of New York, for instance, writes to his correspondent in Boston to meet him at the telephone office at a certain hour. The telephone office in each city consists of a series of little rooms with telephones in them. The two merchants enter corresponding rooms at the hour named, and locking the doors converse at their ease. They may shout as loud as they please and nobody else will hear them. Again, it is a rainy morning, and Mrs. Smith does not want to get wet. She calls on the central office to connect her with Mr. Jones, the butcher. It is done, and she orders her meats for dinner. Or she is lonely of an afternoon, and the central office man having, by her request, joined her wire with Mrs. Brown's, the two spend an hour very enjoyably in cutting up Mrs. Robinson. So with offices and houses, or workshops, and many other things. Its possibilities may be enlarged upon indefinitely.

It is a fact that when the commercial long distance telephone business was started, in the middle 80's, it was necessary for users of that service to go to the company's office to make their calls, on account of the unsuitability of subscribers' lines for long distance talking. It was not the practice, however, to write a letter in advance, and there is no record that the talkers found it necessary to lock the doors.

It will be noticed that the central office operator of the future is referred to as a "man." None of these early prophets—not even the inventor of the telephone himself—envisioned the fact, later proved by experience, that men and boys were temperamentally unsuited to the exacting duties of switchboard operation, and that this work was destined to be performed by members of the opposite sex.

The final quotation is from the *Operator*, a telegraph journal, which afterward became the *Electrical World*, and the reader will detect a certain amount of exaggeration, and perhaps the willingness, on the part of the author, to "take his readers for a ride." To appreciate properly this glowing tribute to scientific achievement, it is necessary to know that the invention of the microphone, or loose-contact transmitter, resulting from the work of Hughes, Berliner and Edison, had

been announced to the scientific world during the preceding month:

Operator, June 15, 1878

The veracious man of science tells us that, by the aid of the microphone . . . we may hear the prancing of a fly on a metallic disk with all the distinctness of a horse cantering over a bridge. Even the insect's respiration may be clearly heard, like the wheezing of an asthmatic elephant. Soon we can bring appliances to bear to gather up the minutest sounds, magnify them to a tremendous volume, and hurl them to any desirable distance. We are assured that we shall be able, not only to listen to the tramp of the tiniest insects, but to hear the growing of the grass, and the ripple of the sap ascending beneath the bark of the tree. The seething of the magic alchemy in the laboratory of the leaves, as they transmute the grossness of earth and air into forms of beauty, and the bravery of the summer's green shall become as audible as the clatter of a common workshop. Then will the dreaming poet, as he lays him down in the woods or field to feel the thrill of nature's voices, surround himself with batteries, disks, and wires, and bring to his ears the clash and roll, the hum, the ripple, and the clang of a Titanic orchestra. Nor will it be necessary to go to the fields and subject one's self to the depredations of bugs and ants to get all the benefit of the magnified and multitudinous sounds that keep the atmosphere vibrating. They may be gathered from their haunts in field and by brook, amid the gloom of forests and along the sounding shore, and be brought by wire from every direction to some grand hall in the busiest metropolis, and there let loose for the edification of gathered crowds. Perchance instruments may be devised whereby these myriad notes may be commingled and controlled to the utterance of most excellent music. Who knows but even the music of the spheres, the voice of the smallest star dust that

"in his motion like an angel sings
Still quiring to the young eyed cherubins,"

may be made perceptible to mortal hearing. The voices of earth and heaven may perchance unite in one tremendous symphony through the agency of the symphone that is yet to be invented.

But there are other possibilities hardly less interesting. Not every sound, whether of nature or of art, is either soothing or exhilarating. The nerves of man are subject to torture as well as exaltation. It is not given to all persons to be gently "Hushed with buzzing night-flies to the

SOME EARLY TELEPHONE PROPHECIES

slumber"; and to some the shrill clarion of the mosquito on his midnight marauding is anything but soothing. Cats that make night hideous with their private wrangles, and cackling poultry that spoil the morning nap, these utter sounds that no one would wish to have magnified. And although there might be a cacophone devised as an instrument of torture, to be used, perhaps, as a means of punishment for the worst class of criminals, as something more terror-striking than death itself, yet the virtuous and humane would be concerned for some apparatus that would utterly destroy and nullify horrid and disturbing sounds. Why cannot ingenuity apply itself to discovering some means for eliminating the sound waves from the air at will, so that the cat on the back fence, with arched back and tail erect, may be "seen and not heard," and the mosquito quench his raging thirst for gore without exasperating the victim with his whining, sniveling outcries? And while the combined telephone and microphone might, in the household, enable one to gather up most interesting whisperings, and accurately gauge the pulsations of two hearts that beat as one, it would be a peculiarly precious boon to be able to sit in one's office all unconscious of outer sounds. The strident and indirect upbraidings of the mother-in-law, the peevish cry of other people's children, the brawl of beggarly passers-by, the din of hand-organ in the street or piano in the adjacent boarding house, and all the distracting noises that make life weary . . . might be smothered by a faithful antiphone of some sort, whose function it should be to take the life out of every intruding sound. But no volume of moderate compass would suffice for the setting forth of all the possible results of the invention of phones and their application to the manipulation of sounds. We can only give the imagination a hint, and let it work in this most fascinating field, and meantime we must await the slow processes of invention before a full realization of the benefits of the latest uses of electricity.

The reader's first reaction to this highly imaginative article—which was unsigned—will probably be one of bafflement. All of the predictions set forth in the preceding pages have been realized, or are capable of realization. Here we have prophecies and desires which remain unfulfilled, after a lapse of nearly sixty years. Although it is possible to detect extremely minute sounds, there is no record that any human ear has heard the respiration of an insect, the growing of the grass, or the ripple of the sap ascending beneath the bark of a tree.

No "symphone" has been invented to unite the voices of earth and heaven in one tremendous symphony. There is as yet no "cacophone," for which we should be thankful. Had such a fiendish instrument appeared prior to the presentation of the "Mikado," its inventor would surely have been down on the list of persons who never would be missed. And no "anti-phone" has been devised to completely eliminate from the air itself all horrid and disturbing sound waves.

With regard to the "symphone," however, it is safe to say that the anonymous author who facetiously predicted its arrival would have been greatly astonished had he been in Constitution Hall, Washington, on April 27, 1933, and heard the perfect transmission and reproduction of symphonic music, played in Philadelphia, with the illusion of hearing each separate instrument from its proper position on the stage.

And as for the "anti-phone," although its full requirements have not been realized as yet, nevertheless, practical means, in the way of filters, have been devised for reducing the potency of unpleasant sounds, under certain conditions, and, if it is any comfort to the sufferer, the modern sound engineer can measure the magnitudes of these offending noises, and express them in decibels.

R. B. HILL

Notes on Recent Occurrences

OVERSEAS SERVICE EXTENDED TO PUERTO RICO AND KINGSTON

BELL System overseas telephone service has been further extended in the West Indies with the establishment of radio telephone circuits between the mainland of this country and the islands of Puerto Rico and Jamaica. Service to the former was opened on February 20, and to the city of Kingston, Jamaica, on April 3.

The service with Puerto Rico was inaugurated by an exchange of greetings between Secretary of the Interior Harold L. Ickes, in Washington, and General Blanton Winship, Governor of the island, in San Juan. Others taking part in the inaugural ceremonies included Chairman Anning S. Prall of the Federal Communications Commission, and officials of the Department of the Interior. K. S. McHugh, Assistant Vice President of the American Telephone and Telegraph Company, acted as master of ceremonies.

Those participating in the ceremonies at the New York end of the Kingston circuit were Sir Gerald Campbell, British Consul General; Richard W. Lawrence, Chairman of the Executive Committee of the New York Chamber of Commerce; and T. G. Miller, Vice President, Long Lines Department, American Telephone and Telegraph Company. Speaking from Kingston were Sir Edward Brandis Denham, Governor of Jamaica; George Armstrong, United States Consul; Ellis Levy, President, Jamaica Chamber of Commerce; Lewis Ashenheim, Chairman, Jamaica Telephone Company; and A. G. Blackwell, Manager, Direct West Indies Cable Company.

The telephone link between Puerto Rico and the mainland

consists of a short wave channel between the radio telephone stations of the Bell System at Miami now handling service to South and Central America and other West Indian islands, and stations of the Porto Rican Telephone Company, near San Juan. The same stations in Miami, working with stations of the Direct West Indies Cable Company at Kingston, provide the link between Jamaica and the mainland. The charge for a call between New York and either island is \$18 for the first three minutes and \$6 for each additional minute.

DR. FRANK B. JEWETT IS AWARDED FRANKLIN MEDAL

THE Franklin Institute of the State of Pennsylvania has announced the award of the Franklin Medal this year to Dr. Frank B. Jewett, President of the Bell Telephone Laboratories, Inc., and Vice President of the American Telephone and Telegraph Company. The presentation of the gold medal and certificate will be made on May 20 in the Hall of The Franklin Institute in Philadelphia at formal exercises presided over by President Nathan Hayward of the Institute.

The Franklin Medal is awarded annually from the Franklin Medal Fund, founded January 1, 1914, "to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, acting through its Committee on Science and the Arts, have done most to advance a knowledge of physical science or its applications." Dr. Jewett will receive the Medal "in recognition of his many important contributions to the art of telephony, which have made conversation possible not only from coast to coast, but from this country to the other side of the world—contributions of which some were made by him alone, and some by him in collaboration with other workers in the great laboratory of research which he organized and which he has directed with such signal success."

NOTES ON RECENT OCCURRENCES

A similar medal will be awarded at the same ceremonies to Dr. Charles F. Kettering, General Director of the General Motors Research Laboratories and Vice President of the General Motors Corporation, Detroit, Mich. The late Gen. J. J. Carty, former Vice President and Chief Engineer of the A. T. & T. Co., was a recipient of the Franklin Medal in 1916. Other distinguished scientists who have been the recipients of the Franklin Medal during recent years are: Sir William Henry Bragg, Dr. John F. Stevens, Sir James H. Jeans, Dr. Willis R. Whitney, Prof. Philipp Lenard, Dr. Ambrose Swasey, Dr. Paul Sabatier, Dr. Orville Wright, Dr. Henry Norris Russell, Dr. Irving Langmuir, Dr. Albert Einstein, and Sir John Ambrose Fleming.

RADIO ENGINEERS HONOR DR. CAMPBELL

DR. GEORGE A. CAMPBELL, for many years a prominent member of the Bell System's scientific and engineering staff until his recent retirement, was awarded the Medal of Honor of the Institute of Radio Engineers by vote of the Board of Directors of that organization at a meeting held on April 1.

The medal was established in 1917 and is the senior medal awarded by the Institute. It is awarded annually in recognition of noteworthy inventions and developments in the electrical communication art. It is not given solely for any specific achievement in the radio field, but rather to recognize a number of contributions, extending over a lifetime. In Dr. Campbell's case, one of the factors which determined his selection for the honor was the contribution he has made to the theory of electrical networks. This theory finds application in the loading coils and wave filters used extensively in telephony.

Those who have received the award in the past include a number of European and American scientists whose names

stand high in the field of electrical communication. These include: E. H. Armstrong, E. F. W. Alexanderson, G. Marconi, R. A. Fessenden, Lee de Forest, John Stone Stone, M. I. Pupin, G. W. Pickard, L. W. Austin, Jonathan Zenneck, G. W. Pierce, P. O. Pedersen, G. A. Ferrie, A. E. Kennelly, J. A. Fleming, S. C. Hooper and B. van der Pol.

Formal presentation of the medal will take place at the Eleventh Annual Banquet of the Institute, at the Hotel Statler, Cleveland, O., on May 12.

BELL TELEPHONE QUARTERLY



XV

JULY, 1936

NO. 3

TELEPHONY—CHILD OF ORGANIZED
SCIENTIFIC RESEARCH

THE GROWING USE OF TELEPHONE
“CONFERENCE SERVICE”

ALL AMERICA AT THE CONVENTIONS

THE BELL SYSTEM HISTORICAL MUSEUM

THE WORLD'S TELEPHONE STATISTICS:
JANUARY 1, 1935

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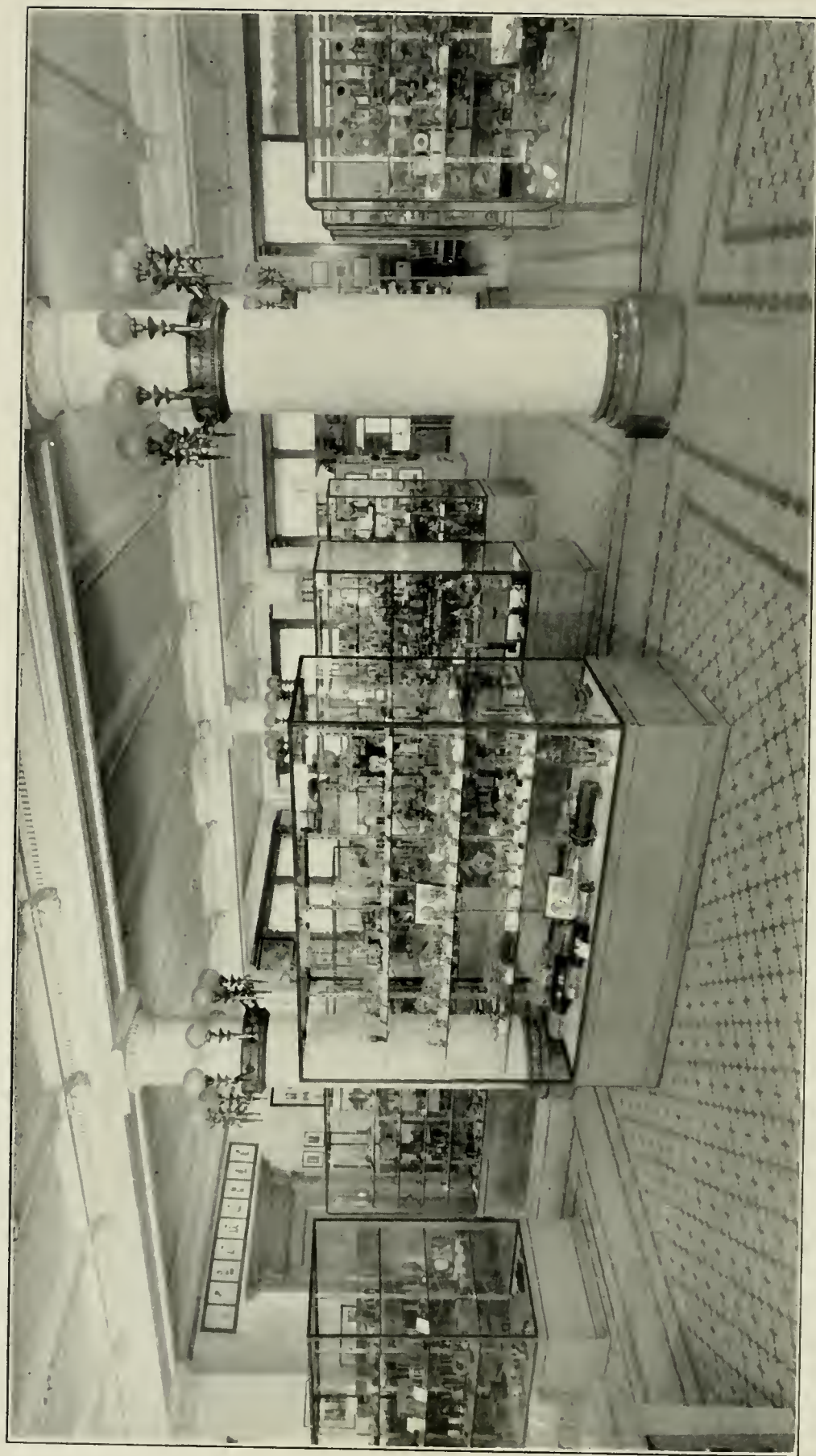
U. S. Naval Academy, 1918. U. S. Navy, 1917-23 (Lieutenant). Reporter, *Springfield Republican*, 1924-1925; *Newark Evening News*, 1925-1927. Publicity Department, Long Lines Department, American Telephone and Telegraph Company, 1927-.

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A GENERAL VIEW OF THE BELL SYSTEM HISTORICAL MUSEUM. AN ARTICLE DESCRIPTIVE OF THE MUSEUM BEGINS ON PAGE 169.

Telephony—Child of Organized Scientific Research

Editor's Note:

Following is part of an address by Dr. Frank B. Jewett, Vice-President of The American Telephone and Telegraph Company and President of the Bell Telephone Laboratories, on the occasion of the presentation to him of the Franklin Medal by the Franklin Institute of Philadelphia, Pennsylvania, May 20th, 1936.

TELEPHONY or, in fact, any form of electrical communication, is truly a child of organized scientific research. It was born in a laboratory, it developed in a laboratory, and with the passing years it came more and more to derive its life blood from the creations of skilled scientists associated together coöperatively in great industrial research organizations. The fact that telephony in our modern world has come to be an extensive and vital part of our social and business structure tends sometimes to mask the dependence of the service on the research men. The huge sums of money invested in plant; the thousands of employees and the necessity of providing for their wages, their comfort, and their continued esprit de corps; the millions of daily contacts with customers; the vast and intricate relationships with government and a host of other things, all of vital importance, which each day have to be properly handled, create a superstructure which makes it easy to lose sight of the fact that, one and all, they are supported by the things which scientific men in laboratories have produced. Without these they would not exist. Further, so long as there is scientific knowledge, existing or acquirable, which can still be applied to better, to cheapen and extend existing modes of electrical communication or to create new ones, the whole superstructure is subject to realignment as a result of what these laboratory men do. Nor

can we stop the tide if we would, unless perchance we are prepared to commit social hara-kiri.

Limitation of time compels me to speak of but a single child of organized scientific research—telephony. What is telephony? Technically, it is all forms of electrical transmission of intelligence in which the ear is the ultimate detector and translator to the brain. Telegraphy, on the other hand, is electrical transmission of intelligence in such manner that the eye is the ultimate detector and translator. The instruments at the sending and receiving end of the circuit, the type of transmitting circuit, and all the intermediate apparatus may vary greatly without altering the fundamental concept of what constitutes telephony. All that we commonly think of as telephony, all radio broadcast, and all the sound portion of talking pictures is telephony by this definition. They are so treated in the research laboratory, since they require mere variant applications of a common knowledge and a common technique. Usually, solution of a specific problem in one sector solves or helps to solve problems in the other sectors.

EARLY RESEARCH WAS CARRIED ON INDIVIDUALLY

A brief look backward will show clearly why telephony in all its parts is so completely and necessarily a child of organized scientific research. When Dr. Bell made his discovery, it was a scientific achievement involving the results of scientific discovery by others. It was not, however, organized research in our present-day sense. Nor was the work which followed in the years immediately succeeding the Bell invention. It was scientific and much of it was done under truly laboratory conditions, but in the main it was the work of scientists, engineers, experimenters and inventors working independently and more or less individually. This was a necessary condition and one always present in any new art. Everything had to be developed, facts of a simple character

TELEPHONY

had to be obtained, men had to be educated and, above all, underlying science had been explored only in surface spots.

For a few years there was much to do in developing more efficient and rugged transmitters and receivers, in evolving satisfactory signaling devices, and in working out switching arrangements for the expeditious connecting together of subscribers' lines. All of these things could be done by ingenious men familiar with and borrowing from the older telegraph art. In these years commercial telephony was wholly a community affair in which the transmission efficiency of simple line structures more than sufficed to provide for the inefficient terminal apparatus possibilities. Nor were there in these local systems many problems of interference either between telephone lines themselves or from other electric circuits. The lines were so few and so scattered that the simple expedient of physical separation usually sufficed when occasional trouble occurred. Further, there were no particular problems of space or cost in the central offices arising out of great congestion of line terminals.

TRANSMISSION AND SWITCHING PROBLEMS SOON AROSE

Gradually, however, as instruments were improved in efficiency and reliability and as the use of this new means of distant communication increased, the need for and possibility of intercommunity service developed. With it arose the beginnings of those transmission problems and the problems of vast and intricate switching offices which have been our main concern for four decades.

At first the transmission problems were overcome by using larger wires, by a radical departure from the ground return circuit art of telegraphy to an all metallic circuit, and by a substitution of high conductivity hard-drawn copper wire for the iron or steel wire previously employed.

In the central offices, application of ingenuity in the reduc-

tion of part sizes and their more orderly arrangement, combined with clever circuit arrangements, sufficed for a time.

Soon, however, it became increasingly apparent that the obvious and easily followed roads of advancement were becoming fewer, narrower, and progressively more expensive. Likewise, the limitations of a purely individual type of trial and error attack on the numerous problems pressing for solution became manifest. Were the obvious economic and social advantages of a better, cheaper, and more universal development of telephony destined to be unduly hampered, if not blocked, by the difficulties immediately ahead?

SCIENTIFIC TECHNIQUES AND TRAINED MEN WERE NEEDED

Fortunately for telephony and for many other arts as well, the two decades from 1880 to 1900 were extremely prolific years in the fields of fundamental science research and in the rapid adaptation of educational curricula to the continually mounting store of new knowledge. A survey of telephony's problems in the light of what had happened in these two sectors convinced us that the problems were not insoluble. If, however, the solutions lay hidden in this newly acquired and rapidly growing fund of knowledge and in the techniques which had evolved it, it was equally apparent that they could only be had through the introduction of those same techniques and of men trained in them and with an understanding of the facts already unearthed.

Nor was the indicated course merely one simply of introducing men and techniques and proceeding along the essentially individualistic lines of the established development art. Most of the techniques, as well as most of the new knowledge, had been evolved by scattered individual effort in institutions of learning. Rarely, if at all, had the problems solved involved the necessity of simultaneous solution of a host of other problems in widely scattered fields; rarely was time, so vitally important in industry, the essence of the undertaking.

TELEPHONY

If, therefore, our salvation lay in the direction indicated, its attainment required a radical step forward in the use of science and scientific men. Moreover, it could not mean a complete break with all the values of the past. It must be a gradual introduction designed to refractify these old values, to indoctrinate the older order of men already successful in an earlier battle with a sense of the power inherent in the new tools, and so ultimately to reorganize the forward movement.

Was it possible to organize scientists for a mass attack on problems which might involve almost anything in the whole domain of the physical sciences? Could we analyze these problems in sufficient detail to permit of attacking the several parts successfully and on time? Could we synthesize our solutions in a form to make them commercially available? Would fundamental science continue to produce new knowledge in sufficient amount to justify the grand adventure? These and a hundred other similar questions confronted us and had to be answered affirmatively very largely on faith.

THREE DECADES OF RESEARCH IN TELEPHONY

From the vantage point of our present knowledge, the questions seem trivial and the answers obvious. Thirty-five years ago it was otherwise. Then industrial research in any field, as we now know it, was sub-embryonic. We had little experience, and none at all in fields where the problems were so vast or the stakes of success or failure so great.

The story of the past three decades is far too long even to be touched on here. To a very large extent it is the story of the research department of the Bell System—the story of an organization which in that time grew from a handful of men to the present Bell Telephone Laboratories with its staff of approximately 4,500 men and women. What can be enumerated briefly are some of the more important direct results of organized scientific research in the field of telephony. They

are results which in the main could not have been obtained without it.

It has given us our vast urban telephone networks without unsightly pole line structures; it has made not two blades of grass grow where one grew before but literally scores of pairs of wires grow in cables in the same space where one grew before and has provided the means which make these present fragile filaments of copper more efficient conductors of speech than their much more robust ancestors. It has greatly improved the efficiency, uniformity, reliability and convenience of the instruments we use in our homes and offices. It has revolutionized the art of switching until our more recent central offices bear scant resemblance to those of even the World War period. It has enabled us to extend the range of commercial telephony from less than 1,000 miles until there are no land distances over which speech of adequate intensity and quality cannot be given. At the same time it has so altered, cheapened, and improved the transmission circuits that today we can afford to have enough of them of proper character to permit of completing practically every connection asked for while the calling party remains at the telephone.

THE FRUITS OF ORGANIZED ENDEAVOR

It has developed radio telephony so that ocean barriers to speech have been destroyed, and likewise communication made possible to and between ships, airplanes, and all moving vehicles. It has developed radio broadcast and initiated a great new industry in the realm of disseminating news, music, and entertainment. It has made possible the simultaneous transmission of a host of non-interfering messages over the simple circuit which before its advent carried but a single message and that but poorly. Finally, it has made possible the interconnection of all these things in any random fashion and in addition has given birth to a great new industry where sight and sound are joined for our edification and education.

TELEPHONY

Many of our present-day services of telephony could never have been done at all without the aid of organized scientific research. None of them could have been accomplished so completely and cheaply, had we had to depend on the fortuitous outcome of unorganized endeavor, no matter how scientific its elements. The history of each success in every major and minor achievement of telephony's organized research is generically the same—analysis, concentrated attack on the elementary problems, and synthesis to a final answer. Every branch of mathematics and of the physical sciences, as well as many of the biological sciences, has been examined and drawn on for aid; every new piece of knowledge which might be useful has been scrutinized; new knowledge in the fundamental sciences has been sought, to the end that a better, cheaper, and more nearly universal telephone service might be afforded the people of the United States. As an example of how far afield the quest has taken us, might be mentioned the fact that some years ago it became apparent that the whole structure of sound scientific research in many branches of telephony was based on having a much better quantitative knowledge of the exact mechanism of speech and hearing than then existed. We had then to adventure into the realms of physiology and psychology. We have obtained much of what we sought. Incidentally, we have, I think, enriched those fields.

WHAT DOES THE FUTURE HOLD?

So much for the present. What of the future of organized scientific research in the field of telephony? Has the day of its zenith been reached? Have so many frontiers been crossed in the past thirty years that there are few that remain to be conquered? What is the future of this corps of highly trained scientists?

It is true in electrical communication, as it is in every other field, that a frontier once crossed can never again be a frontier. To those of us for whom the spanning of a continent or an

ocean with speech channels was once a challenge, our success closed the door forever to later generations. Today there is no barrier of distance or in the character of terminal station to telephony anywhere on the globe where man may be. The establishment of telephone channels is purely a matter of economics or of policy. But does this mean that in the future there is little place for an agency which for three decades has demonstrated its creative power in ever increasing measure? I think not, although it is obvious that the character of many of the objectives will be different from those of the past.

ORGANIZED SCIENTIFIC RESEARCH MEETS NEW CHALLENGES

So long as efficiency and cost are factors limiting the free and untrammelled use of telephony, or so long as there is hazard to its operation through the development of interfering services, there will continue to be a challenge to organized scientific research. New increments of knowledge in many fields of science are potential tools in the field of a more efficient telephony. They may be knowledge as to new materials, new discoveries in mathematics, or new concepts of atomic structure; they cannot be neglected and a conquest of their possibilities will be as intriguing and profitable as any of the grosser adventures we older men have engaged in.

Even on the grosser side the future still presents the challenge of how best to render *all* the services of electrical communication. We have already gone far enough, as a result of our research work, to know that from a technical standpoint all of these services are part of a common science. We have still, however, to work out, partly in the field of science and engineering, partly in that of economics, and partly in that of government, the best way of handling the problem. The final answer will be determined very largely by what organized scientific research has to say on the subject.

We have built up a great organization of scientifically trained men competent to contribute new knowledge of a

TELEPHONY

fundamental character, to attack expeditiously and efficiently any problem which presents itself, and with a demonstrated capacity to produce results of a value far exceeding the expenditure of time, effort, and money required in their production.

Without venturing on the unsafe ground of speculation as to what further research in fundamental science may produce, we nevertheless know that there are still great vistas of possibility for scientific research in the fields of telephony and its sister services. It is still true here, as it has been for many years past, that each advance opens the way to yet other advances. For example, in the fields of multiple transmission of messages over relatively cheap and simple conductors, we know that it is theoretically possible to go vastly farther than we are yet prepared to venture. How far it will be commercially practical to go is something for the future to determine. In the last analysis, it is a problem for organized scientific research, to which finally the cold impersonal judgment of economics is applied.

Modern telephony, which is surely the child of organized scientific research, seems to me destined to continue in this status for many years to come.

FRANK B. JEWETT

The Growing Use of Telephone "Conference Service"

TELEPHONE conference service is a relatively new feature in the communications field offering interesting possibilities of substantial development. This service is appropriately named because it makes possible what the dictionary defines as an "appointed meeting for counsel, deliberation or discussion on some special matter." It is probably true that, inasmuch as two persons can "confer," every telephone conversation can be abstractly termed a "conference." But conference "service," as an offering of telephone companies, affords the opportunity for the meeting of several minds, instead of two only, "for deliberation or discussion," and its growing use reflects typical American impatience with obstacles and limitations, and the nation's typical imaginative adoption of instrumentalities that serve to overcome them.

There are four general types of conference usage. The first relates to telephone conferences entirely inter-office in character or with one or more participants outside the office, that are arranged for at a private switchboard on the premises of a telephone customer. The second comprises conferences between several individuals in a local area. The third refers to the use of toll and long distance circuits in order to interconnect several persons. The fourth includes instances where loudspeakers at one or several points have enabled groups instead of individuals to enjoy the advantages of the service.

PRIVATE BRANCH EXCHANGE CONFERENCE SERVICE

For telephone conferences of the first of these four categories, arrangements are made at the customer's private switchboard which permit the switchboard attendant to interconnect

GROWING USE OF TELEPHONE "CONFERENCE SERVICE"

several telephones. The usual arrangements contemplate the interconnection of as many as five telephones, two of which may be reached over outside lines; but special arrangements are possible whereby a larger number of telephones on the premises may be interconnected.

Such arrangements are obviously valuable to organizations with various departments located on different floors of a large building or in different buildings, since officials and department heads can "confer" without leaving their offices, with a consequent saving of time and energy. To call one or more to the "conference" who are not in the organization but who have business pending with it is the next step in utilizing these arrangements. There are routine usages in abundance to show how conference equipment on the premises "proves in." For example: The head of a large department store, faced with an urgent merchandising question, confers by telephone with buyers without requiring them to leave their departments. A chief engineer discusses production matters simultaneously with the mill superintendents concerned. Officials of a national bank use inter-office conference facilities for arriving quickly at a common understanding. The partners of a law firm talk together by telephone with a client, including a clerk or stenographer in the "conference" when necessary. A relief organization uses conference service so that several of its personnel may participate in discussions with officials at state headquarters. An electric power company has conference connections set up when conditions require immediate instructions or reports that involve foremen, load dispatchers, substation attendants or others, and crew foremen are enabled to interrupt the discussion and report to the conferees simultaneously. A chief engineer of a large construction project uses conference service every day to talk from some outside point simultaneously with several engineers at headquarters.

LOCAL EXCHANGE CONFERENCE SERVICE

The examples just cited suggest the infinite variety of ways in which conference arrangements at a P.B.X. can be utilized to distribute information, exchange views, and reach decisions.

The same mutual benefits result from telephone conferences to individuals without private switchboards by utilizing the conference arrangements at the central office of the telephone company. Wherever the equipment has been installed, there are trained "conference operators" ready to interconnect up to six or more telephones. A local conference call may take the place of a series of individual calls, or may actually be a group meeting of several people. The potential value of this service as a time saver for busy people cannot even be estimated. There is obvious practical value in a communications practice that permits an automobile distributor to "meet by telephone" with five agents simultaneously, or the manager of a charity drive to hold nightly committee meetings of field executives without interruption of their canvassing, or a church official to hold bi-monthly meetings by telephone with his associates. It is reported that the by-laws of a school for crippled children have been revised to legalize transactions of trustees decided upon during their frequent telephone conferences. The following newspaper account in a western paper (of May 13, 1936) suggests how local conference service, here reported as a novelty, is destined to win approval everywhere because of its demonstrable worth:

MOSIER GETS BUSY COMMITTEE BY THE EARS FOR CONFERENCE

It's no longer a horse and buggy town we're living in. We have graduated in one fell swoop from the tank town class. City Manager Orval Mosier has introduced that ultra-metropolitan innovation, the "telephone conference."

At 1 p. m. or thereabouts on the epochal other day, Mosier summoned his secretary, Alice McElroy.

"We must have a meeting of the charities and solicitations

GROWING USE OF TELEPHONE "CONFERENCE SERVICE"

committee," he said. "The members are busy people. And we are busy people. Please arrange a telephone conference."

Rushing to her telephone, Mrs. McElroy called the conference operator, gave the names and phone numbers of the committee. Three minutes later the city manager's phone rang.

"Your conference is in session, sir," piped a sweet voice. It was a big moment at city hall.

"Call the roll, please," Mosier spoke into his phone, probably feeling a little silly because not a soul was with him in his office. From an adjoining office, Miss McElroy, her phone also hooked into the circuit, began:

"Granville Scanlan . . . Clyde Kemery . . . L. J. Bullis . . . M. L. Simpson . . . Mae Erbacher . . ."

* * *

After each name a different voice responded. The conference was on, with seven phones scattered over the city linked in the conference circuit.

"We'll now proceed with the regular order of business . . ." Mosier went on. And they did, approving four applications for permits to sell benefit tickets in the city.

Exactly 22 minutes later, a voice said, "I move we hang up," and the motion was unanimous. Six receiver clicks. Total cost of the conference was \$1.75 at 75 cents for the first five minutes, 25 cents for each succeeding five minutes or fraction thereof.

The event went off without a hitch. Whenever someone wanted the floor, he broke in at the first pause, "L. J. Bullis speaking . . ."

"Mr. Bullis has the circuit," Mosier would reply.

"It worked perfectly," Kemery commented Wednesday. "We got as much done as we would have in an hour and a half in Mr. Mosier's office."

LONG DISTANCE TELEPHONE CONFERENCES

In an annual report issued a few years ago by the American Telephone & Telegraph Company, the statement was made that the year's most striking development was the growth of the "long distance habit."

This habit is now expressed statistically in the records showing a daily average of some two million and a half toll and long

distance telephone conversations in the United States. They indicate the importance of communications in a country of 3,000,000 square miles, populated by 127,000,000 people and with consequent far-flung inter-relations that are beyond computation. The vast activities relating to production, distribution, buying, selling, transportation, education, recreation and government, and the social relations of 31,000,000 families, are not only aided but stimulated by America's unrivaled telephone service, and long distance conferences by telephone are therefore as inevitable as individual conversations. With reduced night rates now available all day Sunday, a constantly growing "habit" seems certain of development.

There was a "sample" long distance conference a few months ago that must have stimulated the imagination of the radio listeners who heard it. The occasion was a broadcast commemorating the fiftieth anniversary of the incorporation of the American Telephone & Telegraph Company, and was marked by many features that showed how the modern telephone art has enlarged the scope of man's voice. One of these features was a conversation among five widely separated individuals.

These participants were Miss Grace Moore in Hollywood, California; Admiral Cary Grayson, President of the American Red Cross, in Washington, D. C.; "Dizzy" Dean, the well-known member of the "Cardinals" baseball club, in St. Louis, Missouri; Dr. Karl T. Compton, President of the Massachusetts Institute of Technology, in Boston; and Mr. Rufus Dawes, President of the Century of Progress Exposition, in Chicago. With special telephone circuits functioning, for broadcasting reasons, instead of the usual long distance circuits, the radio audience heard exactly what the five participants heard as they chatted with each other regarding the significance of the anniversary. But the practical significance of their talk as a program feature was the usefulness to the nation inherent



A GROUP OF OPERATORS HANDLING A LONG DISTANCE TELEPHONE CONFERENCE AT CONFERENCE POSITIONS OF THE LONG DISTANCE SWITCHBOARD AT 32 SIXTH AVENUE, NEW YORK CITY.

GROWING USE OF TELEPHONE "CONFERENCE SERVICE"

in long distance conference service as an agency of multi-point intercommunication. To speculate on this usefulness one has only to think, first, of the web of wires ready to function as channels of speech between any of more than 70,000 communities in the United States, and second, of the myriad situations arising in government, industry, agriculture or family life wherein a common understanding among several individuals is needed in the quickest possible time. The potential uses are as varied as the constantly changing needs and interests of the people. Actual uses already recorded indicate how mountain ranges, prairies, deserts, and even oceans seem non-existent as barriers to a meeting of minds when the conference service comes into play. The business stories are those of the improved efficiency in management because of conferences of a headquarters with its branches; of the stimulation given to selling campaigns because of multi-point discussion of competitive conditions; of important agreements involving many persons reached at a saving of precious hours. They are all exhibits in an American Exposition of Ways of Saving Time and Cutting Costs. They all illustrate how a long distance conference can serve many simultaneously in the same manner that a long distance conversation can serve two, as is shown in the following instances:

An attorney, who was handling a receivership settlement, was informed while out of town and just about to start on a vacation trip, that changed conditions in the case required his immediate presence at home. Rather than give up his vacation plans, he held a telephone conference with interested parties in three distant cities. In one five-minute conference, costing \$18, a complete understanding was arrived at.

The division sales manager of a manufacturer and distributor of office machine equipment wanted to awaken enthusiasm for a sales campaign by talking personally with field salesmen who lived in the territories which they covered. The sales man-

ager held a telephone conference with the salesmen at their homes. He outlined to them the campaign plans and the details were discussed fully by all concerned. As a result, sales quotas were established, enthusiasm was inspired, and the manager had definite knowledge of the action that would be taken by each member of his sales force.

With a mid-western meat packing business there were frequent changes in price, and it was important to have the field representatives posted with as little delay as possible. It was also important to the sales manager, for his guidance, to have the opinion of the field as to changing local conditions. These matters had been handled by individual toll telephone calls, telegrams, and fast mail. Something better was wanted and so conferences by telephone are now held periodically by the district sales manager and attended by agents in different cities. Not only can headquarters now keep in close contact with the field and announce at first hand policy and price changes simultaneously to the agents, but the latter, brought together by telephone for discussion, understand changes better and make clearer their reactions to them. A considerable saving in time and money has been effected.

An interstate motor freight transportation company had been attempting to coördinate the movement of its trucks between points up to a hundred miles apart by individual toll calls, telegrams, and mail. This resulted in delays, errors, misunderstandings, and additional communications due to points raised by one branch affecting another. Now in a six minute meeting by telephone each day, costing \$4.55, all branches and the home office are simultaneously informed of the number of trucks leaving each terminal, their destination, and the amount of freight each terminal will have to handle. Changes are discussed and rearrangements made "in the presence of all." This provides up-to-the-minute control of trucks and insures economical operation.

GROWING USE OF TELEPHONE "CONFERENCE SERVICE"

"GIVE TO A GRACIOUS MESSAGE A HOST OF TONGUES"

What of the incidents in the use of long distance conference service where loving sentiment instead of business details have been the traffic of the wires? What point they give to Shakespeare's line, "Give to a gracious message a host of tongues"! Many hearts of young and old have indeed been gladdened

Family, 7000 Miles Apart, Exchange Phone Greetings

MERCED OFFICE STOCKTON RECORD, Dec. 26.—Members of the Stevenot clan exchanged Christmas greetings Christmas Eve over a span of 7000 miles bridged by radio waves and telephone lines connecting Merced, San Francisco and Manila.

It was 7:30 Christmas morning and mid-summer in the Philippines when Joe E. Stevenot, vice-president and general manager of the Pan A Telephona Company in Manila, called his California relatives at 3:30 yesterday afternoon.

The unprecedented private telephone hook-up was completed within a few minutes to eight phones in the three cities with more than 15 members of the Stevenot family participating in the 22-minute holiday conversation.

Besides Manila's warmth and California's cold, the seven brothers

and sisters discussed gold mining prospects of the family in both California and the Philippines and the general return of business prosperity, according to Archie D. Stevenot of Merced, manager of Hotel Tioga.

On the wire at Merced were Mr. and Mrs. A. D. Stevenot, Mrs. Leonie Christensen and a niece, Miss Rosie Costa of Sonora. At San Francisco were Fred Stevenot, prominent banker and former director of the State Department of Natural Resources, with his wife; Cassie M. Stevenot and Mrs. N. Hildebrand of the bay region, and Mrs. Mae Gericke of Fallon, Marin county. Joe Stevenot was alone in Manila. Besides the brothers and sisters several of their children participated in the conversation. The Stevenots all were born at Angela Camp.

4 Brothers in Phone Reunion

Four brothers, one of whom is M. L. Fuller, United States weather observer here, held a long distance telephone "reunion" Christmas night, the connections covering a span of 1,500 miles.

Mr. Fuller received a telegram earlier yesterday from his younger brother, R. E. Fuller of Evanston, advising him to "be near a telephone about 9 o'clock." At that hour, the weatherman was called to the telephone and found himself in communication not only with his Evanston brother, but with two more, J. E. Fuller of Wilmington, Del., and A. C. Fuller of Cedar Falls, Iowa.

Not only the brothers, but their families as well, joined in the exchange of season's greetings and conversation during the "reunion." It was the first get-together in four years, Mr. Fuller said.

The "reunion" lasted for 10 minutes.

TWO NEWSPAPER CLIPPINGS REPORTING SOCIAL USE OF LONG DISTANCE TELEPHONE CONFERENCE SERVICE

because the far away voices of those absent from the family circle have come together in "conference." Perhaps if the telephone were an animate, sentient thing, it would consider this to be its pleasantest service. Frequently these telephone reunions have been reported in the press. Here is an account from the Peoria, Illinois, *Journal*, of December 26, 1934:

Four brothers, one of whom is M. L. Fuller, United States weather observer here, held a long distance telephone "reunion" Christmas night, the connections covering a span of 1,500 miles.

Mr. Fuller received a telegram earlier today from his younger brother, R. E. Fuller, of Evanston, advising him to "be near a

telephone about 9 o'clock." At that hour the weatherman was called to the telephone and found himself in conversation not only with his Evanston brother, but with two more, J. E. Fuller, of Wilmington, Del., and A. C. Fuller, of Cedar Falls, Iowa.

Not only the brothers, but their families as well, joined in the exchange of season's greetings and conversation during the reunion. It was the first get-together in four years, Mr. Fuller said. The reunion lasted for 10 minutes.

During the same Christmas season another reunion was thus reported in the Stockton, California, *Record*:

Members of the Stevenot clan exchanged Christmas greetings Christmas Eve over a span of 7,000 miles bridged by radio waves and telephone lines connecting Merced, San Francisco and Manila.

It was 7:30 Christmas morning and mid-summer in the Philippines when Joe E. Stevenot, vice president and general manager of the Pan A Telephone Company in Manila, called his California relatives at 3:30 yesterday.

The unprecedented private telephone hook-up was completed within a few minutes to eight telephones in the three cities, with more than 15 members of the Stevenot family participating in the 22-minute holiday conversation.

Besides Manila's warmth and California's cold, the seven brothers and sisters discussed gold mining prospects of the family in both California and the Philippines and the general return of business prosperity, according to Archie D. Stevenot of Merced, Manager of the Hotel Tioga.

TELEPHONE CONFERENCES WITH LOUD SPEAKERS

A recent letter to a telephone company manager reads in part as follows: "We were able to reach about 1200 men in our sales meetings throughout the country. The loudspeaker arrangement worked out very satisfactorily, and it is a splendid thing in getting an idea over to a sales organization in a quick way. Our organization, as a whole, was very enthusiastic and very much pleased with the service."

That seems to sum up the story. Groups of men in widely

scattered cities—distant executives with a message for all—conference service with loudspeakers added—and complete understanding, and unity of action resulting. For along the wires can flow personality to inspire confidence and awaken enthusiasm. There can be spiritual contact. There can be the question asked and the answer returned. Doubts and fears can be removed, management can speak directly and authoritatively. Matters can be settled not only conveniently and quickly but accurately. North, South, East and West can meet together at will. And voices from foreign lands can join the meeting, for, as was said during an historic 'round-the-world conversation by wire and radio on April 25, 1935, there are now "no earthly limits to human speech," by telephone.

It is interesting to note that even before "conference service" became a commercial offering in America, there was one historic international conference by telephone. On February 16, 1928, a thousand members of the A. I. E. E. were assembled in New York for their winter convention. Simultaneously the British Institution of Electrical Engineers was meeting in London. An overseas radio telephone channel, in operation only a year, was utilized to unite the two societies so that, in a joint session, they listened to addresses through loudspeakers and transacted business as though in a single auditorium.

As though in a single auditorium! At the time the experiment was recognized as an impressive demonstration of the telephone art's destiny in the service of mankind. Though not available as a service that can be furnished on a few minutes' notice, the incident serves today to give dramatic emphasis to the significance of the commercially available means whereby individuals or groups, though physically apart, may be united for discussion, debate, and decision. Prophecy need not pause when considering how mankind will ultimately adapt to its needs the service that eliminates the miles when a meeting of minds—a conference—is desirable or necessary at a

particular moment, either as a routine matter or in an emergency. The history of telephone development proves that telephone engineers have led rather than followed the demand for ever better and more useful means of transmitting intelligence, and this history proves also that supply has awakened demand. A time-saving instrumentality cannot fail to make its own market. It seems certain that "conference service" and human need will act and react upon each other just as previous telephone developments have done. It is already clear that a new telephone habit has been born, and there is no question as to its sturdiness and promise.

W. P. BANNING

All America at the Conventions

IN an article that appeared in 1879 in that instructive and entertaining journal *All The Year Round* conducted by Mr. Charles Dickens, a Dr. Lyon Playfair, "a scientific man as well as a politician," made an observation which must have startled not a few of the savants of his time.

"After witnessing some remarkable results obtained by the microphone, used in conjunction with the telephone," says *All The Year Round*, Dr. Playfair "expressed a belief that the speeches of great orators might, in the possible future, be heard by the whole population within five or six square miles."

Dr. Playfair himself would undoubtedly have been rather startled, had some one trumped his prediction with another, foreseeing the entire population of the next generation in the United States not only listening to the speeches of the great orators at a political convention, but—with all the ingenious technique of modern radio broadcasting, which is in itself a remarkable invention—getting a mental picture of the proceedings that was in some respects more complete than that of an actual spectator.

"We now take you to Cleveland," says the announcer in New York—or San Francisco, or New Orleans—and for all practical purposes we are there. From the "previews" of the arriving delegates to the closing scenes we follow the course of events. Chairman Snell bangs the gavel and it is heard in Maine, Florida, Washington, carried to every corner of the nation by a network of Bell System circuits to more than 200 stations of the National, Columbia and Mutual broadcasting chains as well as two score other stations operating independently.

We hear not only the speeches. An intricate system of some

seventy-five microphones, designed by National Broadcasting Company and used by all the broadcasting systems as well as the newsreel producers, enables us to follow every interesting and significant event in the hall. Now we are (electrically speaking) at the rostrum, now we are a few feet in front of the band. Perhaps a delegate is given the floor: the man at the microphone control panel operates a key cutting in a microphone a few feet from the delegate and we hear him as clearly as does the man next to him.

"The next order of business" is taken up with each state in its alphabetical order: We hear the Chairman of the Alabama delegation, "Alabama passes!"—then Arizona, "Arizona yields to Kansas!" Over the network wires comes the uproar that follows, brought to us by a "mike" suspended above the heads of the tumultuous delegates. Over the speaker's platform Columbia Broadcasting System has installed a "Demonstrometer" for registering the amount of noise. The indicator goes to the top and stays there.

The tumult and the shouting dies and a hundred broadcasting specialists move on. "We take you now to Philadelphia." Permanent Chairman Robinson makes his address, an enthusiastic delegate toots a battered cornet, the band plays "Everybody Loves My Baby." Another ingenious array of microphones devised by Columbia Broadcasting System picks up speech, music, noise—there are microphones on the rostrum, beside the band and the organ, and another mike suspended from the ceiling that catches background noise as those ribbons of fly-paper in the old-fashioned grocery store catch flies.

Perhaps there is a pause in the proceedings. Swimming in the sea of conversation that swirls around him, the delegate may wonder what it is all about. The little girl listening to the radio in Yakima could tell him. A "pause interpreter" is on the air to explain it to the audience of x million, listening to the stations of a great radio chain.

At Philadelphia a new method of broadcasting makes its first

News Will Flow Swiftly From Convention to World

Hundreds of reporters surrounding the long speaker's platform, extending 50 feet out in Public Hall. . . . Telegraph operators relaying the reporters' "copy" to expert pressmen in the workroom below. . . . Being transferred to tele-typewriters and telegraphers. . . . newspaper wire services. Efficiency.

A corps of uniformed pages will notify delegates of phone calls.

BIG HOOK-UP READY FOR PHILADELPHIA
Democratic Convention to Be Over 200 Trans- Today.

WIRE MAZE TO AID
Political Broadcasts on the He was in telephone conversati

Delegates Put On Air Wires
phone wires.

WIRES READY FOR POLITICAL FLOOD
telephone lineup.

Long Distance Call To Cong. Martineau
Facilities Needs to Meet

Latter Thinks Early Morning 'Phone Conversation a Joke by Colleagues, But Really Talks to
at Ha

All America at Convention
radio President Phones to Frie in Nomin

President Phones to Frie in Nomin
no conven- en wired.

HEADLINES TELL THE STORY OF THE PART WHICH WIRES PLAY IN REPORTING THE NATIONAL POLITICAL CONVENTIONS.

appearance on the floor of a convention. Roving here and there in the auditorium, an NBC announcer carries with him a micro-wave transmitter. Buttonholing a prominent delegate, he interviews him on the spot, the colloquy being picked up by a receiver at the broadcasting control booth and sent thence to the network.

The curtain is rung down on the proceedings at Convention Hall and we move to Franklin Field. Seated comfortably in our living rooms we can almost feel the rain there and share, in a comfortably detached way, the uneasiness of the spectators as to whether it will turn into a steady downpour. We are glad to hear that it clears up, and settle down to listen to the preliminary speeches.

The handling of these speeches is an ingenious adaptation of "the microphone used in conjunction with the telephone" which had so impressed Dr. Playfair. From a group of eight booths in a building near Franklin Field, telephone wires lead to seventeen points—New York, Chicago, Portland, Ore., and elsewhere. Each terminates in an auditorium or an open air bowl, where local Democrats have gathered to hear the ceremonies.

At 9:45, prominent delegates to the convention enter these booths and address their respective constituents in the various auditoriums and open air bowls. As each finishes, a key is flipped and the local gathering is "cut in" on Franklin Field—and over the great wire network that serves the broadcasting companies they hear the ovation that precedes the President's address.

A striking illustration of the capabilities of the telephone forces on location at Philadelphia was furnished in connection with one of those unexpected developments which are usual on such occasions. At 12:02 P.M., one of the broadcasting companies informed the telephone company that an important interview was going to take place on the steps of the National

Committee's headquarters hotel at 2:15. They would like to put it on the air.

It was the noon hour, with half the force at lunch. They needed a line from the long distance office in the Bourse Building to the broadcasting company's control room some eleven blocks away, another to the headquarters hotel, and wires through the lobby to the scene of the interview.

The interview went on the air at 2:15.

Returning for a moment to our article in Mr. Dickens' Magazine, we find another interesting observation: "Such results," says the writer, referring to the experiments with microphone and telephone, "lead practical men to look forward to the day when one or other of these sensitive instruments will be available for reporting parliamentary speeches with a rapidity and accuracy never hitherto attained."

Practical men of the Press in the United States are already looking *back* to that momentous day, having covered two conventions by means of the telephone and its first cousin, the teletypewriter, with a rapidity and accuracy not only unattained hitherto, but quite undreamed of by the most fantastic prophets in 1879.

For if the convention demonstrated radio's new rôle in our political life, the part played by the Press was no less striking.

From the pencils and typewriters of 800 ladies and gentlemen of the Press a veritable gusher of words is set off that tumbles forth over telegraph wires, teletypewriter circuits and telephone lines to the roaring presses of great dailies hundreds, thousands of miles away.

It is a tremendous mobilization of men and machines for the rapid dissemination of news. We are back in Cleveland: Campaign Manager Hamilton announces that 51 of the Pennsylvania delegation are for Landon in an "interview" with the Press that reaches the proportions of a crowded town meeting, with three or four hundred reporters. The interview ends and the meeting melts with a rapidity not usually seen after an

opera performance. In fifteen minutes the story is on its way across 500 copy desks.

Or at Philadelphia, Senator Wagner is interviewed about the party's platform. Again a flood of copy is converted into electrical impulses, thence into linotype and so into headlines. Perhaps it is late for your morning paper in the East, it just makes the deadline in the Mid-West, while out on the Pacific Coast it is replaced by a later statement sent on by a corps of correspondents that grinds on twenty-four hours a day.

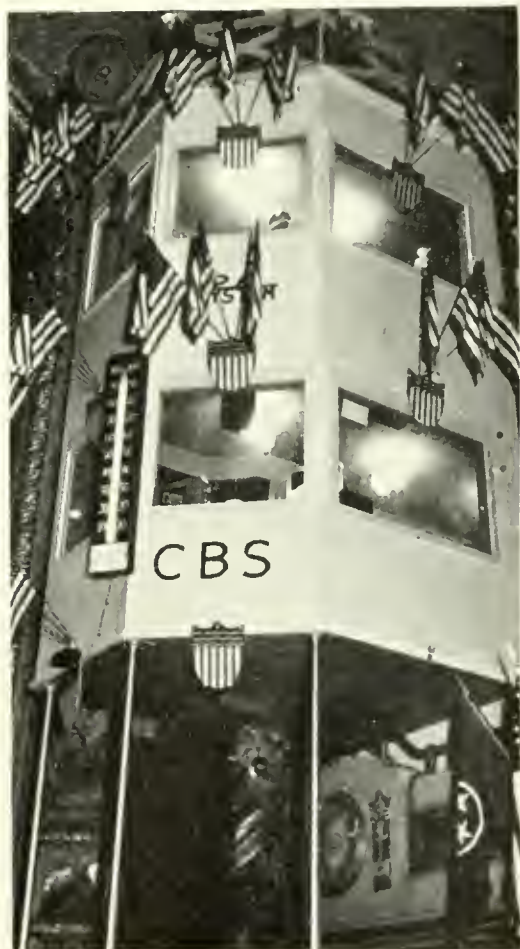
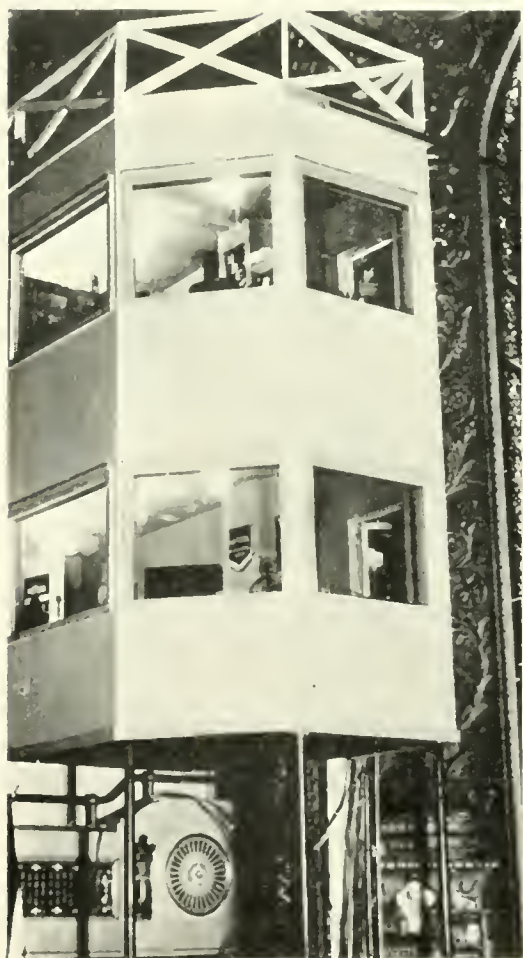
Let us look around at the facilities employed by these reporters, commentators and feature writers from every corner of the United States, from Europe, and even from Australia. Just below the rostrum are teletypewriters, morse keys and telephones—some connecting with the Press "workroom" in the basement that covers two city blocks, some with the city rooms of newspapers and press associations hundreds of miles away.

Down in the workroom more teletypewriters, morse keys and telephones, here and there among an array of typewriters, produce a clattering symphony that will cover the front pages of thousands of newspapers in a few hours; while over at campaign headquarters, in the lobbies of the big hotels, at the railroad stations—wherever the activities of a convention are visible or audible, a flying squadron of the Press is at work with pencil and typewriter—and then the telephone or the teletypewriter.

The Cleveland convention is galvanized by Governor Landon's telegram regarding the platform planks. The teletypewriters and morse keys at the Press platform send a "flash" pulsing over the wires to the copy desks in distant cities. The full text goes down to the workroom and the flash is followed by a complete story from the machines in the workroom. Or at Campaign headquarters in Philadelphia Chairman Farley issues an important statement. Another flash over the wires to distant cities, while the statement and accompanying story



BROADCASTING CONTROL BOOTHS IN THE CONVENTION HALL IN PHILADELPHIA.



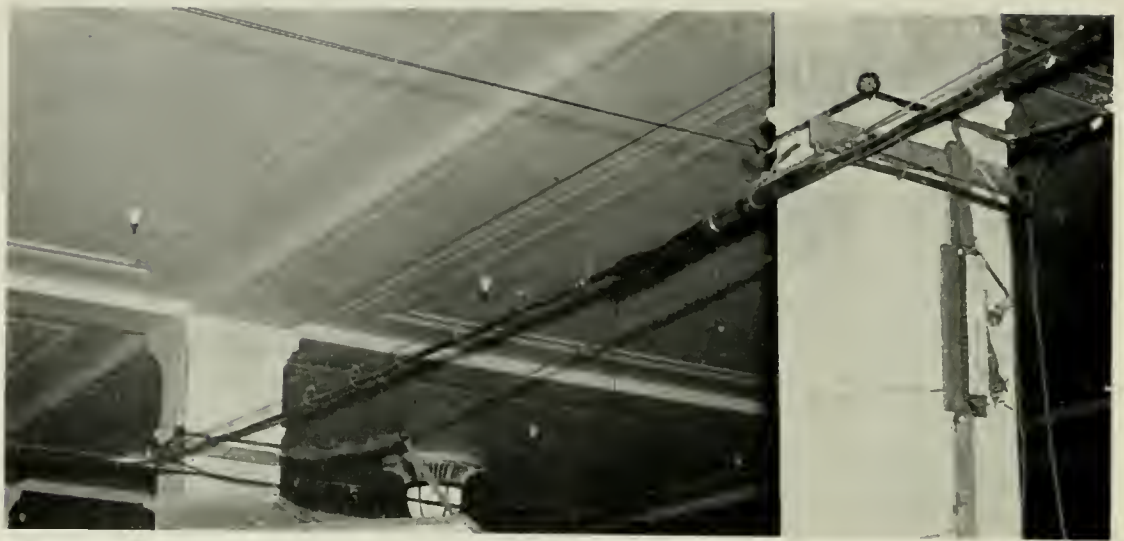
BROADCASTING CONTROL BOOTHS IN THE CONVENTION HALL IN CLEVELAND.



INTERIORS OF BROADCASTING COMPANY CONTROL BOOTHS AT THE CONVENTIONS.



THE PRESS ASSOCIATIONS SENT MILLIONS OF WORDS OUT OVER THE WIRES FROM THEIR HEADQUARTERS IN THE CONVENTION CITIES.



A SPECIAL INSTALLATION OF TELEPHONE WIRES, ENTERING THE CONVENTION BUILDING AS A 400-PAIR CABLE, CARRIES CIRCUITS TO THE NEWSPAPER WORKROOMS.



IN THIS BELL SYSTEM WORKSHOP IN THE BASEMENT OF THE CONVENTION BUILDING, ATTENDANTS ARE CHECKING BOTH TELETYPEWRITER AND TELEGRAPH CIRCUITS, WHILE AT THE TEST PANEL IN THE BACKGROUND ALL BELL SYSTEM CIRCUITS OF BOTH TYPES FURNISHED TO CARRY THE NEWS OF THE CONVENTION CAN BE TESTED.

follow as fast as the writer can tap it out. Or an important personage is met at the railroad station, and the reporter rushes to a pay station and gives the story to the workroom from scribbled notes on a fistful of copy paper.

Nor are all the broadcasting people and the reporters concentrated at Cleveland and Philadelphia. Governor Landon goes to the dentist, the President completes the rough draft of his acceptance speech. Both events are fully reported over the air and in the next revolution of the country's presses.

Of the total of more than 300,000 miles of Bell System circuits employed by the Press, it is impossible to say how much was directly involved in transmitting news from Cleveland and Philadelphia. Certainly a large part of it, for the main Eastern circuits of the Associated Press, the United Press Associations and International News Service, as well as Transradio Press Service, led right through press platforms and workrooms at both conventions.

Moreover, several large newspapers had special circuits to each city. All in all, there is no doubt but that practically the entire network furnished to press associations and newspapers was in regular daily use in connection with news of the conventions.

Not all of the 800 ladies and gentlemen of the Press at the Conventions were turning out words. Shadowing the reporter was the newsphotographer with his flashbulb and his "Smile please, Senator." For this is the day of the candid camera and the monster array of flashlights that illumine the vast auditorium to its Stygian depths with the brilliance of a million candles. The great reading public wants to see these political figures and convention scenes.

And a hundred photographers deploy about the city. At Cleveland, a tumultuous Kansas delegation parades with a covered wagon, or Miss Peggy and Grandfather Landon arrive. At Philadelphia Chairman Farley and Governor Lehman confer, or a loyal Democratic pilgrim arrives on horseback from

Dallas. They are all "light-brigaded" by the photographers.

Down in the workroom the Associated Press has a portable telephotograph set, connected to its telephotograph network. At New York, San Francisco and 23 other cities, a tiny beam of light flickers over a photographic film and in a matter of minutes pictures are in the hands of three-score newspapers.

Acme-NEA Service, International News Photos and Wide-World Photos also have portable telephotograph sets installed in the workrooms and connected to Bell System message circuits, from which they transmit to distant newspapers the lights and shadows of a crowded auditorium, a street pageant or a pretty face.

While broadcasting networks and press circuits carried the greater part of the geyser of words from the two gatherings, there were other Bell System channels that vibrated to a heavy flood. At Cleveland the Ohio Bell Telephone Company installed enough telephones to take care of a city of 10,000—in committee headquarters, in Press offices, in the Auditorium, wherever the tide of bustling citizenry gathered in pools.

In addition to a heavy traffic within the city that kept extra operators at the Company's exchanges throughout the twenty-four hours, the convention set a figure on long distance usage that was some 30 per cent above normal, and 300 calls above the peak set by the floods last March. And its ebb and flow was quite different from normal traffic, reaching its peaks at the most surprising hours: One "at about the sixth hour, when beasts most graze, birds best peck and men sit down to that nourishment which is called supper"—and usually show something approaching apathy for the telephone. And another peak of even more impressive proportions in the witching hours between midnight and 7 A.M.

A not inconsiderable part of this traffic at Cleveland originated with a National Committee whose new chairman had already shown a highly developed technique with the telephone

in a two-weeks long distance campaign in which he talked with the chairmen of the state delegations almost daily.

There were others outside the city who helped swell the traffic. Arrived at his hotel, ex-President Hoover found two telephones, with long distance calls, awaiting him. Ten more backed up behind them before the pressure eased.

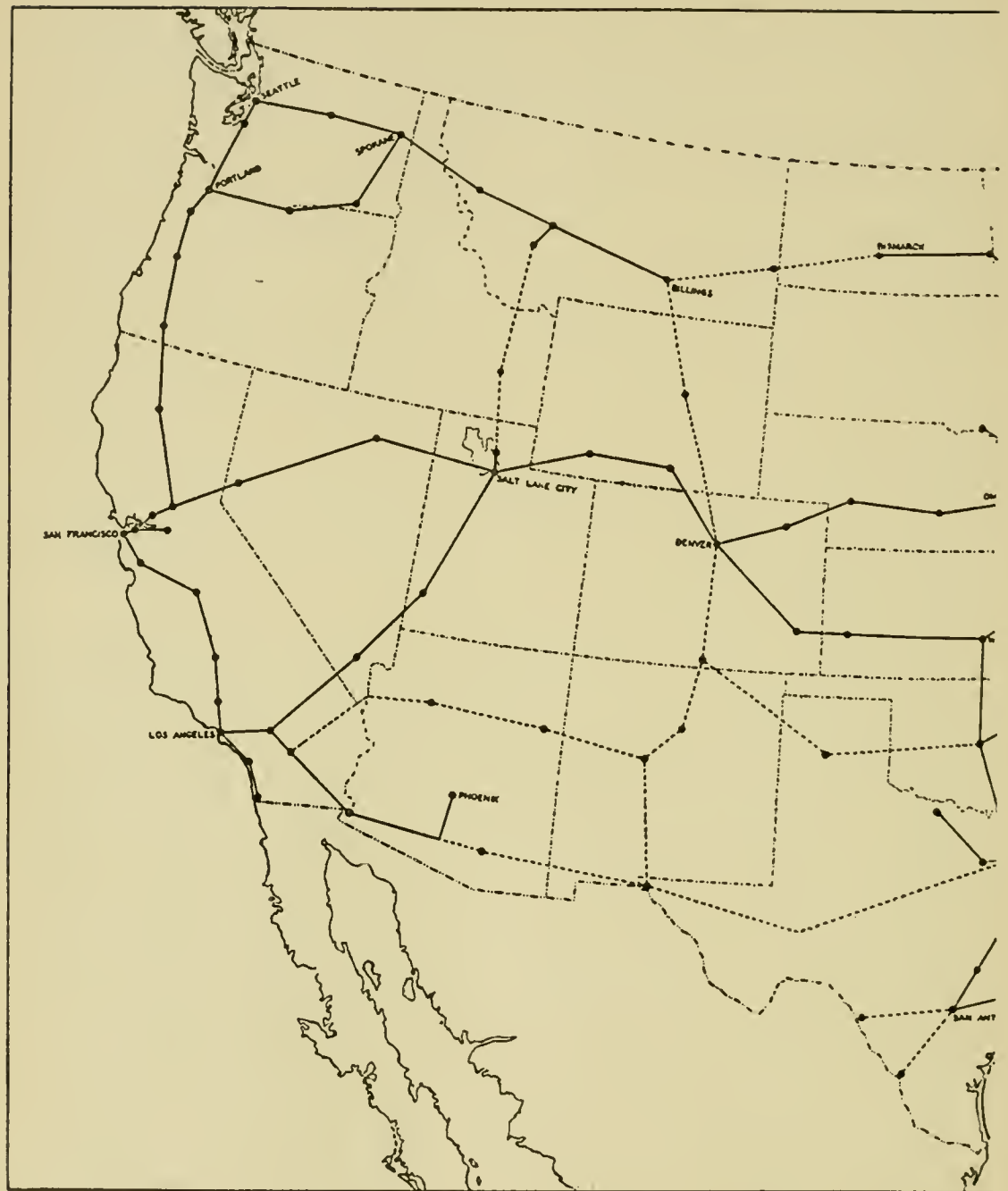
At Philadelphia, another telephone system large enough for a thriving young city was installed by the Bell Telephone Company of Pennsylvania. As in Cleveland, the local and long distance staffs were augmented to take care of a heavy increase in traffic. Down at the Bourse Building in Philadelphia, where the long distance switchboards are, the volume of outgoing calls ranged from 25 to 30 per cent above normal, and it is estimated that the figure on incoming calls was about the same. The crest was just under the great tidal wave of calls precipitated by the March floods.

In addition to the more familiar uses of the telephone by committeemen and delegates, it found employment that was both interesting and novel. In Philadelphia's Convention Hall, the band is in the rear gallery, the organ out of sight under the stage. Under such circumstances, it is easy to foresee something of a musical impasse if the organist launches into "Moon over Miami" at about the same time that the band leader decides the mood of the delegates calls for a Sousa march. The problem is solved by four telephones, one at the organ console, one beside the band leader, one at the rostrum—and one at the camera platform, for the benefit of the newsreels.

Another important accessory of the cameraman, the eight great searchlights in the gallery, is likewise controlled by a telephone party line—one at each light and one at the camera platform.

The use of the telephone at political conventions has ample and fairly venerable precedent. During the Republican convention in 1896, according to a newspaper dispatch at the time, William McKinley, at his home in Canton, O., was in touch by

BELL TELEPHONE QUARTERLY



BELL SYSTEM ROUTES NOW USED FOR PROGRAM TRANSMISSION, OVER WHICH
LINES DENOTE ROUTES OF PERMANENT PROGRAM CIRCUITS;

ALL AMERICA AT THE CONVENTIONS



BROADCASTS OF THE CONVENTION PROGRAMS WERE TRANSMITTED. SOLID
DOTTED LINES DENOTE TEMPORARY OR EMERGENCY ROUTES.

telephone with the convention hall at St. Louis. And in 1936 Governor Landon is in touch with every development at Cleveland over a private line between his office in Topeka and campaign headquarters established by Manager Hamilton; while in Washington, the President turns to the telephone to express to Judge John E. Mack his admiration for the latter's nominating speech.

Another Bell System service made its appearance at the conventions. This was "TWX," or teletypewriter exchange service, in which teletypewriters are interconnected just as two telephones are, through a teletypewriter exchange. At Cleveland and Philadelphia, a number of additional stations were installed for broadcasting companies, newspapers and at campaign committee headquarters. One of the broadcasting companies employed "TWX" to good effect for readjustment of schedules to meet unexpected developments at the convention.

With the development of the electrical transmission of speech and signal, we have come a long way toward the solution of the problem of that "satiabile curiosity" which has been at once the cause of our most acute headaches and our grandest thrills. The Press, the radio and the telephone, all fed from these great wire networks, have enabled us all to enjoy, in our own homes, that tonic pleasure which drew those great multitudes of Athenians to the Areopagus, where, according to St. Paul, "all the Athenians and strangers which were there, spent their time in nothing else but either to tell or to hear some new thing."

We have our newspaper at the breakfast table, and again after the last big-league game of the day; we have our radio set in the living room. We have telephones in easily accessible parts of the house. We have our own Areopagus.

GEORGE G. BREED

The Bell System Historical Museum

LISTED in the "Handbook of American Museums," published by the American Association of Museums, is

THE BELL SYSTEM HISTORICAL MUSEUM

463 West Street, New York, N. Y.

Established: 1913

Control: American Telephone and Telegraph Company

Field: History of electrical communication art

Collections and exhibits: Instruments, models, and photographs illustrating important steps in the development of the electrical communication art beginning with the earliest and extending through the years to the latest developments now in service.

Quarters: Room in executive area in Bell Telephone Laboratories.

Floor space: approximately 3,000 square feet for exhibits.

Admission: Free, during business hours by appointment.

The history of this historical museum started in the autumn of 1912, when John J. Carty, then Chief Engineer of the American Telephone and Telegraph Company, initiated the first step to preserve in one place the relics of the telephone art. They were to be kept in the then Engineering Department of the Western Electric Company at 463 West Street, New York, which in 1925 became the Bell Telephone Laboratories. Early in 1913 Wilton L. Richards was appointed Curator and authorized to collect and classify the material to be obtained. This was a fortunate move, as Mr. Richards had been identified with the laboratory work of the System since 1878, when the Blake Carbon Transmitter was first brought out, and he was familiar with the developments practically from the beginning.

A canvass was made by letter of all the operating companies in the United States and, through the Western Electric affiliations, in Europe and even as far as Australia, for gifts or loans of apparatus, or photographs of old telephone equipment. At

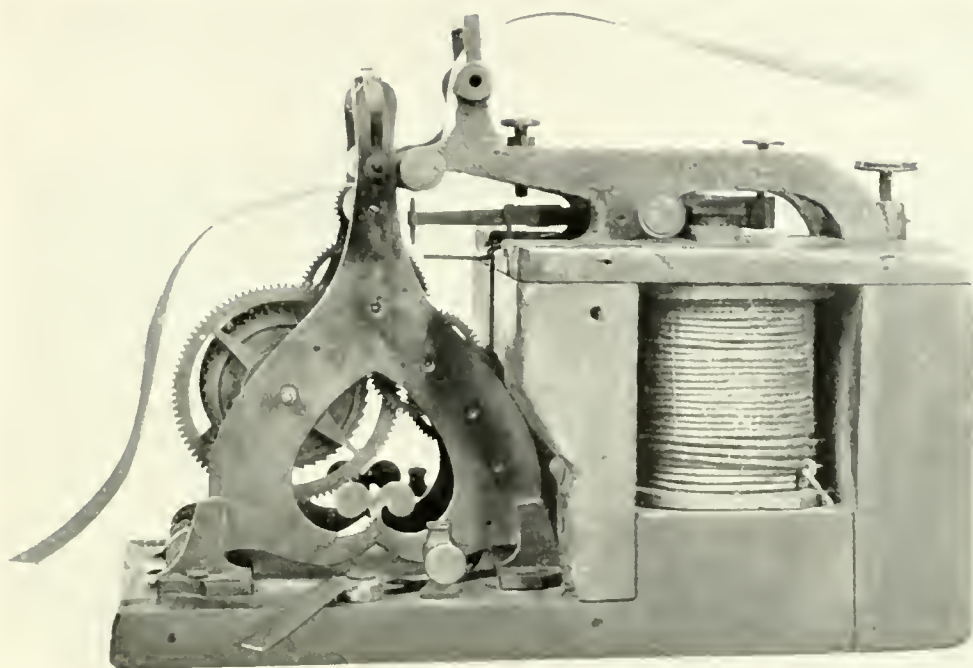
the Telephone Pioneers' Convention that year, a personal appeal was made to its delegates. From the beginning the policy has been to receive gifts or loans and not to purchase any exhibits, and to add the name of the donor or lender to the exhibit card.

The responses from all sources were generous. The larger groups of material came from the collection of early instruments and models of the American Telephone and Telegraph Company in Boston, and from the Western Electric Company Sales Department in New York, where they maintained an exhibit of modern electrical appliances and, as a sideline, some historical telephone apparatus. At first, the museum material was housed in a small room on the seventh floor of the West Street building, then moved to two successively larger rooms on the twelfth floor and finally to the present location on the eleventh floor.

The papers and documents that were collected during the early years were turned over to the American Telephone Historical Collection, organized in 1922 and later named The American Telephone Historical Library, at the American Telephone and Telegraph Company Headquarters, 195 Broadway, New York. This Historical Library collects and preserves the important documents, pictures, and other historical and biographical material relative to the Bell System. This collection emphasizes the economics and personalities of telephony, while the Museum emphasizes the technical advances—the two supplementing each other. William Chauncy Langdon, Historical Librarian, has described the Historical Library in the January, 1924, and April, 1925, issues of the *QUARTERLY*.

On the walls of the entrance aisle to the Museum are two groups of photographs—one of pioneers in the development of the telephone, and the other of the present directorate and executive staff of the Bell Telephone Laboratories.

Today there are nearly 2,000 separate items on exhibit in the thirteen double cases, two pylons, and mounted on the



A Telegraph Receiver Made by Samuel F. B. Morse in 1843.

FIGURE 1



*A Complete Elisha
Gray Printing Tele-
graph Machine, in Use
in 1872.*

FIGURE 2



Exhibits of Developments During the Years 1874-77, Prior to the Commercial Telephone.

FIGURE 3

walls. A general view of the Museum is shown in the frontispiece.

THE TELEGRAPH PRECEDES THE TELEPHONE

The earliest exhibit chronologically is a telegraph receiver (Figure 1) made by Samuel F. B. Morse in 1843, the year before the first telegraph line was opened between Baltimore and Washington, and then follows a group of early telegraph repeaters, sounders, relays and keys in the 1850–1860 period. One historic relic in this group is a telegraph key from Washington, D. C., on which acknowledgment was made of the message from General Grant at Appomattox to Lincoln at Washington that General Lee had surrendered and the Civil War was ended. Pieces of Cyrus W. Field's first, second, and third Atlantic telegraph cables, dating from 1858 to 1866, are also on exhibit. In addition, there is a complete Elisha Gray printing telegraph machine which was used in 1872 (Figure 2). The telegraph was in full swing prior to the invention of the telephone, and it was during some tests on a harmonic telegraph system being developed by Alexander Graham Bell that the principle of the undulatory vibrating current as the basis for speech transmission was verified. So, there is some justification for the display of early telegraph devices before the advent of the telephone.

EARLY EXPERIMENTAL MODELS

Possibly the easiest way to describe what the Museum contains in the form of exhibits and their relations to the developments of the communication art is to make an inspection of the Museum, in the company of its Curator. We begin with the case devoted to the experimental work of Bell and Thomas A. Watson, his assistant, before the telephone became a commercial instrument (Figure 3).

It illustrates a fascinating story—that of the laboratory work

on the telephone prior to its commercial application. Here we may get a picture of the orderly developments from the mental conception to a practical instrument, and also opportunity to record briefly the times, places, and instruments used in the "first" successful tests with the telephone.

In this case the important stages are shown on the second and third shelves from the top, beginning at the left. We first see two original smoked glass records made by Professor Bell and Dr. Clarence John Blake in 1874. They represent sound waves and were made with apparatus that used parts of a human ear as a means of moving the recording stylus. It was these experiments that showed Bell that a diaphragm could, by its motion, reproduce all the elements of a sound wave and led to his conception of the electric speaking telephone, while visiting his parents in Brantford, Canada, during August of that year.

Next are facsimiles of Bell's vibrating reeds for his harmonic telegraph, one a transmitter with its contact for making and breaking the current, and the other a receiver. It was on that memorable day, June 2, 1875, when Bell and Watson were testing a number of these transmitters having various sizes of reeds for the different frequencies, connected by a single wire to a corresponding set of vibrating reed receivers, that the first sounds were transmitted electrically. The adjusting screw on one of the transmitters happened to be screwed down too far. Watson snapped the reed to open the circuit, but the circuit remained closed through the screw while the reed by its vibration over the pole of its electro-magnet was generating that conception of Bell—a current of electricity that varied in intensity precisely as the air was varying in its density within hearing distance of that spring. That undulating current had passed through the connecting wire to the distant receiver which Bell had to his ear and caused its vibrating reed to reproduce faintly the sound of the vibrating spring of the transmitter.

THE FIRST TELEPHONE

Following these exhibits, we see the replica of the telephone made and tested the next day, through which voice sounds were first electrically transmitted—the first telephone. This transmitter has the same electrical structure as the harmonic telegraph transmitter except that the vibrating reed is hinged at the magnet and the free end under the pole-piece of the electromagnet is secured to a large gold beater's skin membrane stretched over the mouthpiece. The varying intensities of the speech sounds caused the skin diaphragm and the attached reed to vibrate and the vibrations of the reed generated a current varying in proportion to the sound intensities. The receiver at the other end of the line was a harmonic vibrating reed receiver the same as used by Bell the day before.

These two tests, June 2 and June 3, 1875, were conducted in the building at 109 Court Street, Boston, Mass., occupied by Charles Williams, Jr., Manufacturer of Electrical Supplies. Watson, who was employed by Williams, had been assigned to make Bell's experimental apparatus and to assist him in his work. The June 2 test with the harmonic telegraph instruments was made in the two adjacent front rooms on the fifth or attic floor. For the June 3 tests, these rooms were so close that the voice carried through the air and would interfere with the tests over the wire. Watson, therefore, ran a wire from one of these rooms down two flights of stairs to the third floor of Williams's shop, ending it near his own work bench in the rear. This first telephone, often referred to as the "gallows frame" telephone, was connected to the line terminating near Watson's bench and the vibrating reed receiver to the other end in the attic room. Voice sounds were plainly heard over this first telephone line but they were not sufficiently distinct to be intelligible. Bell's conception in 1874 of the speaking telephone was thus verified on the instrument tested on June 3, 1875.

Several modifications of the gallows frame telephone were made immediately afterwards. Two of such are shown in the left corner of the bottom shelf of the case.

THE LIQUID TRANSMITTER

The next important step is the "liquid" transmitter of March 10, 1876, seen immediately to the right of the gallows frame telephone. This is a replica of the telephone through which the first articulate words were transmitted and understood at a distance over a wire. Bell applied to this transmitter the principle of an electric spark arrester he had been developing for some time previous for use with his multiple telegraph. In this he regulated the resistance between two wires by dipping their ends in a vessel of water, varying the resistance by changing the depth to which the wires were submerged. In the telephone, a wire rod is attached to the stretched membrane and projects downward just dipping into the cup of acidulated water (dilute sulphuric acid). With the vibrations of the diaphragm the wire rose and fell in the liquid, producing changes in the resistance of the circuit through the rod and liquid. This caused corresponding changes in the electric current passing over the wire through the vibrating reed receiver with the resulting reproduction of the original sounds.

To the right of the liquid transmitter is the original wire over which the first complete and intelligible sentence was transmitted and at its right is a replica of the vibrating reed receiver.

This first sentence, "Mr. Watson, come here, I want you," was transmitted on the evening of March 10, 1876, between two rooms at 5 Exeter Place, Boston. Bell had moved his laboratory from Williams's attic at 109 Court Street, in January, 1876, for more privacy and had rented two rooms, again in an attic, at the Exeter Street boarding house. The room facing Exeter Street was used as his bedroom. The other, at the rear looking out on the back of the buildings on Hayward Place, was

fitted as his laboratory. The test wire ran between these two rooms. On this night, the liquid transmitter was in the laboratory and the vibrating reed receiver was connected to the wire in the bedroom, in which Watson was stationed for the test. Bell accidentally overturned the acid of a battery, spilling some on his clothes. His call to Watson, that first sentence, was an appeal for assistance. Watson could not answer, as he had only the vibrating reed receiver, so he rushed down the hall and into Bell's laboratory exclaiming, "Mr. Bell, I heard every word you said,—distinctly."

The original wire in its own glass case has other historic associations. When the transcontinental telephone service was formally opened on January 25, 1915, in the ceremonies held in New York and San Francisco this wire was placed in the circuit at New York, where a replica of Bell's gallows frame telephone was used as a transmitter by Mr. Bell, who repeated that famous first sentence to Mr. Watson, who was at the other end of the line in San Francisco. On January 23, 1931, Mrs. May Bell Grosvenor, a daughter of Mr. Bell, spoke through another replica with this original wire in the circuit addressing in a clear voice a gathering of more than 4,000 people at a meeting of the National Geographic Society in Washington, D. C.

APPARATUS USED IN DEMONSTRATIONS

The instruments at the left of the third shelf in the case are a single pole membrane transmitter and two iron box receivers, replicas of those demonstrated at the Philadelphia Centennial Exposition in 1876. During the demonstration before the judges of the Exposition and guests on Sunday afternoon, June 25, 1876, Mr. Bell spoke through the transmitter at a distance in the hall over a line connected to an iron box receiver near the table of miscellaneous telephonic and telegraphic apparatus exhibited by Bell. The first person to listen with the receiver was Dom Pedro, Emperor of Brazil, who exclaimed, "My God—it talks." Among those who witnessed the demonstration

that day were Sir William Thomson, Joseph Henry, Elisha Gray, and other men of science.

This transmitter was an evolution of the gallows frame type, with an armature composed of a small disc of thin sheet iron or steel glued to the center of the membrane diaphragm. While the liquid transmitter was the prototype of all the forms of variable resistance transmitters which were developed later, it would not prove a commercial device, and Bell devoted his energies to perfecting an instrument with a vibrating iron or steel unit in a magnetic field.

The iron box receiver was the ultimate of the vibrating reed receiver, a ring of iron with the adjustable center core and helix and a round diaphragm of iron or steel as the vibrating member. And we still use the circular iron diaphragm in our present day receivers.

The next exhibit to the right is an oversize iron box receiver made by Bell to be used in transmitting speech from Boston to Philadelphia. There is no record that this test was ever carried out, but this instrument with its high resistance winding on the helix was tested successfully over an artificial line having a resistance approximating 350 miles of telegraph line. Bell's reasoning that the resistance of the coils of wire in the transmitting and receiving instruments should be higher for the higher resistances of the longer lines was verified in these tests.

We can touch upon only the high spots of these strenuous days. The next exhibit is a replica of one of two similar telephones used in the first "long-distance" two-way or reciprocal telephone conversation. The small iron disc on the centennial transmitter was changed to a large thinner iron disc almost the size of the membrane itself. The mouthpiece was omitted and this structure operated equally well as a receiver and as a transmitter.

This conversation was held on the evening of October 9, 1876, using a telegraph line of the Walworth Manufacturing Company between their office in Boston and their factory in

Cambridgeport, a distance of about two miles. The test was satisfactory and for the first time reciprocal conversation was carried on successfully over the same wire by persons using the same kind of instrument both as transmitter and as receiver.

In passing it should be recalled that the first long-distance telephonic transmission occurred in Canada during August, 1876, between Paris and Brantford, a distance of eight miles. At Paris, an iron box receiver was connected to the line and at Brantford a membrane transmitter. The transmission was in one direction only. The return had to be made by telegraph.

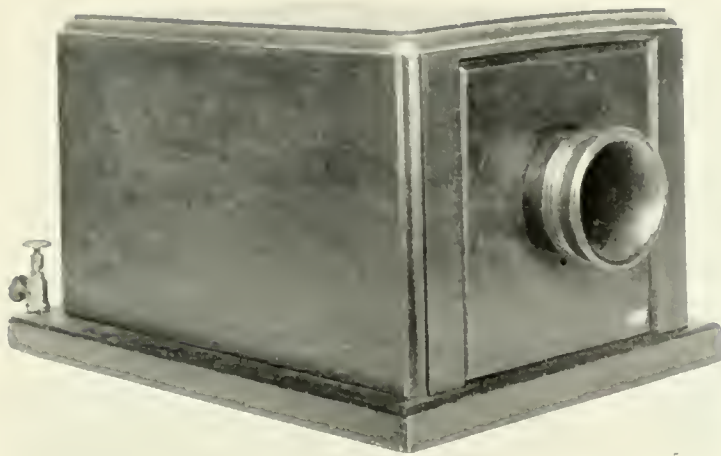
THE PERMANENT MAGNET TELEPHONE

The next and final exhibit illustrating a major change in development is shown at the right end of the third shelf, the telephone with the permanent magnet replacing the previous electro-magnetic structures and a complete iron diaphragm in place of the disc of iron attached to a membrane. The diaphragm was secured to the front of the box cover into which was inserted a mouthpiece to concentrate the sound vibrations to the center of the diaphragm, and there was a screw adjustment for bringing the magnet, coil winding and pole-piece to the proper space behind the diaphragm. This combination was developed some time during December, 1876, prior to Bell's departure for his father's home in Brantford, Canada, on December 22, 1876. It was disclosed in Bell's second telephone patent, No. 186,787, application filed January 15, 1877, granted January 30, 1878. This design gave such superior results that all previous forms of membrane receivers and transmitters were then discarded. It operated equally well as a transmitter and as a receiver, and this type, known as the box telephone, became the first form of commercial telephone in 1877.

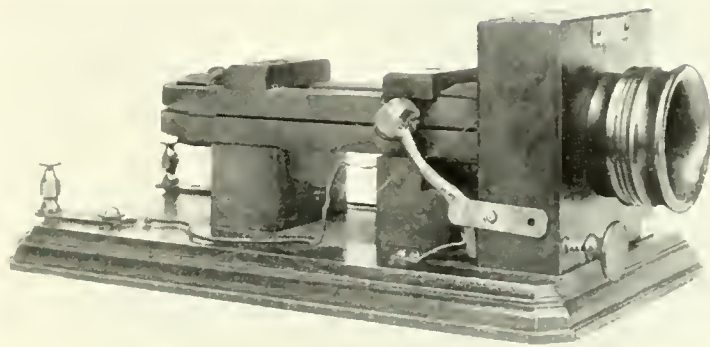
OTHER EXPERIMENTAL MODELS

Before passing to the commercial instruments, let us glance briefly at the other experimental models in this case. On the top shelf we see at the left three replicas of Bell's efforts in multiple or harmonic telegraphy, a current interrupter, a tuned reed receiver and a harmonic telegraph receiver. To the right are shown a group of models of vibrating reeds referred to as "Figure 5," and several transmitter and receiver units referred to as "Figure 7," in Bell's first telephone patent, No. 174,465, application filed February 14, 1876, granted March 7, 1876. These models were made some time later to prove to different courts during litigation that Bell's patent specifications disclosed structures that would operate successfully. The models of "Figure 7" have the same structure as the original gallows frame telephone; those with the large openings tapering down to the membranes to concentrate the sound vibrations on the diaphragms were used for transmitters, and those with the cones to concentrate the received vibrations to the small openings held to the ear were used for receivers. All of Bell's transmitters and receivers, with the exception of the liquid transmitter and the vibrating reed receiver, could be used for both transmitting and receiving, although the best results were obtained when used as described above.

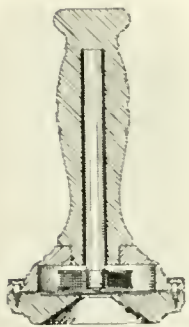
On the bottom shelf we see, beginning at the left, two modifications of Bell's gallows frame telephones; a large iron diaphragm supported on three legs, used in June, 1876, for both transmitting and receiving with electro-magnets of different types; a large permanent magnet exhibited at the Philadelphia Centennial for illustrating the production of magneto-electric currents corresponding to sonorous vibrations; a replica of the liquid transmitter of March 10, 1876, also shown at the Centennial; a double pole membrane transmitter with two electro-magnets similar to the single pole Centennial transmitter; and lastly, a modification of the box telephone, on the shelf im-



*Box Telephone, the
First Commercial Tele-
phone: 1877.*



*Box Telephone with
Addition of "Watson's
Thumper"; Cover Re-
moved: 1877.*



*Cross-section
of "Butter
Stamp" Hand
Telephone:
1877.*



*Large Rubber
Hand Tele-
phone: 1877.*



*Hand Re-
ceiver: 1902.*



*Hand Re-
ceiver: 1912.*

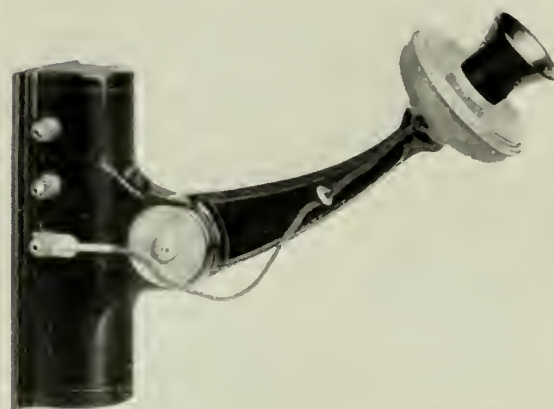
FIGURE 4



Huddell's, or Long Distance, Transmitter: 1886.



Solid Back Transmitter: 1890.



Bracket Transmitter: 1891.



Handset Transmitter: 1934.



"Gilliland Harness" Operator's Set: 1880.



Operator's Set: 1930.

FIGURE 5—continued

mediately above, in which the single permanent magnet with the single coil of wire is replaced by a compound horse shoe magnet with two coils.

"Where are the originals of all these instruments?" is a question often asked. A few are in the Smithsonian Institution at Washington, D. C. Most of the rest suffered the fate of the large majority of subsequent development models—changed almost beyond recognition in the further experimentation to produce better instruments; and some have been lost.

Leaving the embryonic stage of the telephone, we will now pass on to the developments of the telephone from the time of its commercial introduction.

TRANSMITTERS AND RECEIVERS

Transmitters and receivers, the two most intimate parts of the telephone system from the subscriber's standpoint, follow. From the first designs down to the latest present standard instruments, there are in the collection originals of the first box telephones, large, cumbersome affairs made in the spring of 1877 and promptly modified in design, with some reduction in size. These box telephones were used alternately as transmitters and as receivers, the subscriber having to twist his head for each operation. Then the small "butter stamp" hand telephone, the prototype of the present hand receiver, was developed—also used for talking and listening, changing for each operation by a twist of the wrist instead of the head and sometimes getting the twist reversed to "talk with the ear and listen with the mouth." There were four types of wooden hand telephones, then five types of hard rubber telephones, all developed in 1877. The large box telephones were further modified and reduced to less than half their size by placing the coils and diaphragm parallel to the magnets to mount of a vertical wall to be used as transmitters, while the hand telephones became simply the receivers. These combinations persisted until the latter part of 1878, when the Blake hard carbon button transmit-

ter superseded the wall box type, but the instruments so far considered were all developed during 1877. In early 1878, when switchboards came into commercial use, the various auxiliary devices, such as bells, ringers, party lines and privacy systems thrived, and they made quite presentable outfits at the subscriber stations.

With the opening of the first commercial telephone line on April 4, 1877, from Williams's shop in Boston to his home in Somerville, three miles away, it was not a question simply of talking and listening. How could a person be called to the telephone? Tapping the end of a pencil on the diaphragm produced a comparatively sharp report in the distant telephone, but continued tapping bent the diaphragms out of shape and Watson, Bell's only laboratory assistant, had to go out and renew diaphragms. This took time and energy, and to save himself he designed a hammer to strike forcibly the diaphragm on its edge, where it was secured to the front of the box, by means of a push button. This made a much louder sound and saved the diaphragms. It was known as Watson's "thumper," for at the beginning of the use of the telephone there began the long series of developments of the auxiliary devices that have been carried on to the present day to continually improve the ease and speed with which people may be placed in communication.

From 1878 on, switchboard operators' receivers and transmitters came into the picture, and our exhibits show every type of receiver that has been standardized and used in the Bell System from its inception to the present day. There are 77 different types of standard receivers on exhibit. A group of box telephones and receivers of different periods are shown in Figure 4.

Next follows the transmitter display. Beginning with the Francis Blake, Jr., hard carbon button transmitter, the first Bell commercial variable resistance type appearing in the Fall of 1878, we find several modifications both for subscribers' and

operators' uses until the final one appeared in 1885. Between these dates we find three types of transmitters of Berliner's design and two of Edison's which were used in certain localities for a short period. There is also a McKinney transmitter, a modification of the Blake transmitter, for use by switchboard operators. In the final Blake transmitter are also found the contributions of Berliner and Edison.

During 1886, the first granular carbon transmitter appeared. It was called the Hunnings' or long distance transmitter. In 1878 Hunnings, an Englishman, patented a transmitter using a chamber partly filled with pulverized engine coke, a light, porous form of carbon. The American rights to this invention were later purchased by the Bell Company and the commercial instrument, after considerable laboratory development, appeared with granules of hard anthracite coal, which was found by Edison to be superior to pulverized engine coke. Next, we find a granular carbon button replacing the hard carbon button of the Blake structure, and in 1890 the so-called "solid back" transmitter designed by Anthony C. White, in which the carbon button had its rear electrode secured to a metal bridge at the back and the front electrode to the diaphragm. This rugged structure superseded all previous types and was in use in all Bell transmitters for regular telephone service until the advent of the present-day handset transmitter, first brought out in 1927. From 1891 through to 1935, the date of the latest standard instrument, we find numerous types of transmitters, varying from one another in design. Among them may be found the high and low resistance buttons for common battery and local battery service, transmitters on large cast brackets and later on formed steel brackets, side damped and centrally damped diaphragms, a series of Blake transmitter boxes with solid back units replacing the hard carbon buttons, and other changes, the group showing continued improvement from all standpoints—efficiency, design and manufacture. There are 118 different types of standard transmitters on exhibit. A

group of transmitters of varying designs, and two operators' sets, are shown in Figure 5.

On the wall opposite the transmitters, we find an enlarged, mechanically operated, cross-section model of a transmitter and hand receiver, with dry batteries and an induction coil symbolizing the exchange apparatus between the two stations (Figure 6). This has proved an extremely interesting and instructive exhibit in that it illustrates in an easily understood manner the relation between the vibration of the transmitter diaphragm caused by the speaker's voice, the transformation of the sound waves into a varying electric current, and the reverse action at the receiver where the varying current causes the receiver diaphragm to vibrate in the same manner as the transmitter diaphragm to produce sound waves in the listener's ear. No matter what the distance between the transmitter and receiver, be it 10 feet or 10,000 miles, or even around the globe, the vibrations of these two diaphragms must correspond in order to transmit properly a telephone message.

DESK STANDS AND HAND TELEPHONE SETS

Next we see the evolution of the telephone desk stand, from the Blake transmitter on an upright pedestal in 1879 through the years to 1922, when the dial appeared on the base. Adjacent to these are the handsets, the earliest one dated 1879 and the latest 1930. Some of these are shown in Figure 7.

It is interesting to note that the handset of 1879 was invented by an American, Mr. Robert G. Brown, then an engineer for the Gold and Stock Telephone Company in the Telephone Exchange in New York City. During this year, Mr. Brown went to France to install a telephone system in Paris and he took with him the handset idea. In America, this early type was used only by the switchmen in the central offices. It was equipped with an Edison type transmitter which was later superseded by the Blake type which operated best in a vertical position.

THE BELL SYSTEM HISTORICAL MUSEUM

SUBSCRIBER SETS

Our last group of apparatus intimately associated with the public is the subscriber or telephone sets that began with the introduction of switchboards early in 1878. There is one whole case full of these instruments as well as a few mounted on one of the pylons and on the exhibit board nearby. The earliest set is that used with the New Haven switchboard of January, 1878. The exhibits include practically every kind of set made under license of the Bell Company by different manufacturers until the Western Electric Company became the manufacturer for the Bell Company in 1882. Among them are sets and miscellaneous secrecy switches made or designed by Williams, Davis and Watts, Post, Gilliland, Standard Electrical Works, Wotton and Gentry, Chinnock, Prescott, Anders, Phelps, Doolittle, Cheever, Currier, Carey, and Vail. In the early days, the instrument was usually known by the name of the person who contributed some specific feature to its design and many were the ideas that were put into use throughout the system during these times. The latest types of magneto and common battery subscriber sets are also on display. Two subscriber sets are shown in Figure 7.

TELEPHONE AND TELEGRAPH CABLE

The first telephone lines were made of iron wire, a single conductor with a ground return. A sample of the iron wire installed in 1879 between Au Sable and Black Rock, New York State, only recently came into our possession. As early as December, 1877, hard drawn copper wire, developed by Thomas B. Doolittle, was used on a few telephone lines. Eventually it almost entirely superseded iron wire for use in toll circuits. We have samples of the first lot of hard drawn copper wire made by Doolittle, and of the copper wire of the long distance line between Boston and New York which was opened in 1884. With the ever-increasing use of the tele-

phone, the open wires became too numerous for comfort and steps were taken to develop cable, both aerial and underground. Our exhibits of cable development, both telephone and telegraph, are shown in Figure 8.

On the upper right of the top shelf are seen sections of the Havana-Key West submarine telephone and telegraph cables, three laid in 1921 and a fourth in 1931, the last having the same message capacity as the first three combined, due to improvements in the design and materials. The later cable includes for the first time paragutta, developed in these Laboratories to replace gutta percha for insulation of the conductor. There are also pieces of the Catalina Island-Long Beach, Cal., submarine cable laid in 1923, which replaced the radio link between these two places. On the left are shown deep sea sections of five transoceanic telegraph cables laid in the Atlantic and Pacific oceans and having permalloy tape continuous loading. These were laid in 1924-1926. The introduction of permalloy continuous loading was an outstanding development and it increased the speed capacity from four to five times over that of earlier cables. On the second shelf, beginning at the right, are samples of Cyrus W. Field's first, second and third Atlantic telegraph cables of 1858, 1865 and 1866, respectively; other miscellaneous telegraph cables; samples of the high frequency stranded conductors of 1915, developed in these Laboratories; and, at the left, samples of the coaxial cable, the late development of a high frequency conductor capable of carrying over one million cycles for an ultimate capacity of 240 or more simultaneous telephone conversations. On the third shelf, we have a rather complete collection of exchange area telephone cables. Beginning at the right are a few miscellaneous early types, including the glass insulated telegraph cable manufactured by the Western Electric Company in 1880 for the Western Union Telegraph Company and laid in Chicago. The first tall exhibit is the 60-pair cotton insulated cable of 1888 pulled through a lead pipe prior to the introduction of the extruded

lead sheath about 1892. Following along to the left, we see the gradual growth in capacity of these cables up to the 1818-pair first used in 1927. To the left of the case, mounted on the sill of the window at the rear, are two exhibits of cotton insulated, rosin oil filled cable, one with lead foil covering instead of the usual sheath and one with an iron pipe covering the splice between two cables. These cables were laid in Philadelphia in 1888 and 1889. On the bottom shelf of the case, beginning at the right, we have the exhibits portraying the development of toll cables beginning with the 30-pair, No. 16 gauge Boston-Lynn cable of 1889 down to the 282 circuit No. 16 and No. 19 gauge New York-Chicago cable of 1925. Prior to the advent of the vacuum tube telephone repeaters in 1915, the longer toll cables required heavier gauge wire, so we find in the Boston-Washington underground cable conductors No. 16, No. 13 and even No. 10 gauge copper wire. The development of steel tape armored lead covered cable for laying underground without conduit is illustrated in a section of the Fort Worth-Cisco, Texas, cable laid in 1929.

Toward the center of the bottom shelf is a small group of cables of foreign manufacture, and at the left are exhibits of paper insulated lead covered short submarine cables; the one on the extreme left being that laid under the Golden Gate in San Francisco in 1930. This cable is probably the largest submarine telephone cable ever constructed. It is $4\frac{1}{2}$ inches in outside diameter and contains 150 quads of No. 19 gauge and 8 quads of No. 16 gauge conductors. The pylon at the extreme right of the photograph, somewhat out of focus, has numerous photographs showing the line construction on the roofs of exchanges and the heavy open wire lines on poles prior to the introduction of telephone cables. There are also several samples of early insulators.

LINE APPARATUS

We next see developments pertaining to the line. "Mechanical" repeaters of the Shreeve type were in use between 1904 and 1914 for long telephone lines extending from the Atlantic coast as far west as Denver, Colorado, after which the vacuum tube type was used on the New York-San Francisco Transcontinental Line opened in 1915. There are also shown the Campbell (model) and Pupin (original) experimental air core loading coils prior to the commercial introduction of these coils in 1901, with insulated iron wire cores for economy in space and cost of manufacture; and the subsequent developments of air-gap coils in 1913, compressed iron dust core coils in 1916, and permalloy dust core coils in 1927. Nearby is an operating exhibit to enable the visitor, by reading deflections on a galvanometer, to observe the relative permeabilities of brass (non-magnetic), iron (magnetic), and permalloy (super-magnetic). The development of permalloy, an alloy of nickel and iron with a much higher initial permeability than iron, and the technique of manufacturing it in pulverized form for loading coils, has effected a noteworthy economy in manufacture as well as in reduction in the size of the unit coil over the iron dust core coil. Continued research in magnetic materials has recently brought forth an alloy of such electrical characteristics that the size of the completed coil will be still further reduced, by approximately one-third, but this new coil has not yet been placed in the field, so is not ready to exhibit in the museum. In this case, we also find examples of the old wet batteries used for the local subscriber stations in the early days. There is a collection of early insulators, lightning arresters, and fuses; the latest sub-station spark gap and fuse protector; and a few early cable terminals, among which is the "Grace" cable terminal of 1903, which in 1904 became known as the No. 14 cable terminal. Some of this line material is illustrated in Figure 9.



An Operating Model of Transmitter and Receiver; and, Around It, Pictures of Telephotograph Developments, 1923-35.

FIGURE 6



*Blake Telephone
Stand: 1879.*



*Desk Telephone,
with Dial: 1922.*



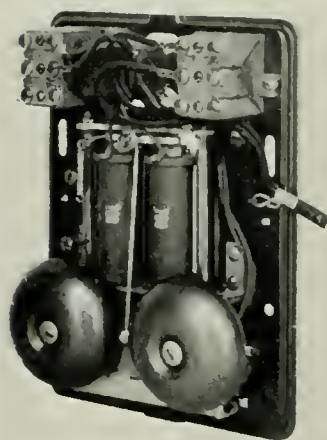
Telephone Handset: 1879.



Telephone Handset: 1930.

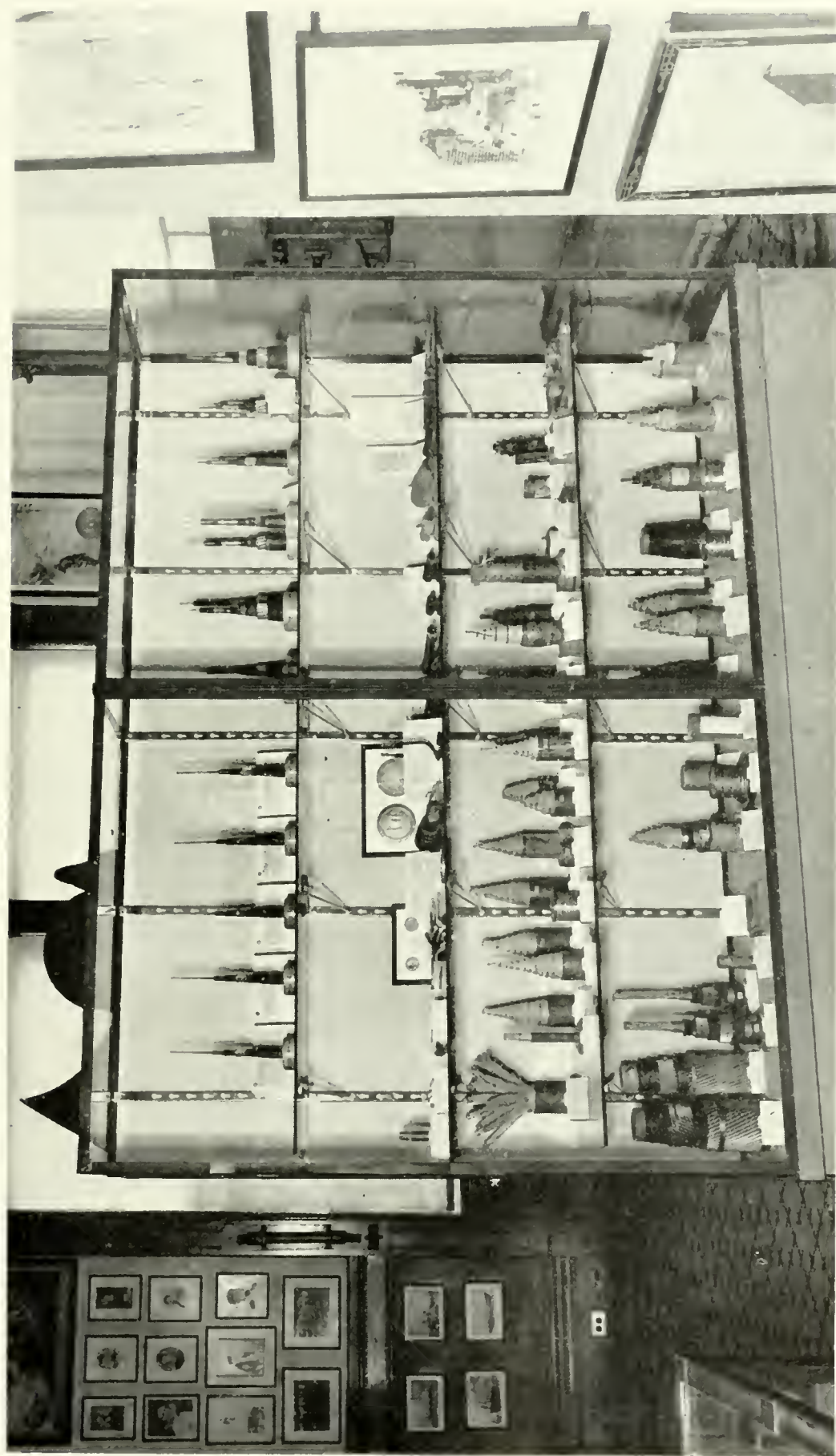


*Subscriber Set, New
Haven: 1878.*



*Bell Box for 1930 Hand-
set, with Cover Re-
moved.*

FIGURE 7

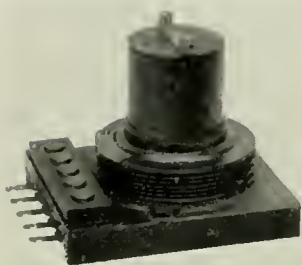


Exhibits of Telephone and Telegraph Cable Development.

FIGURE 8



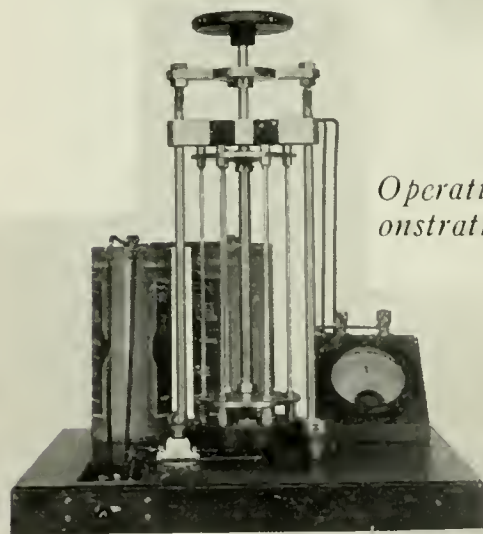
Loading Coils: Campbell, Pupin, 1900; Iron Wire Core, 1901; Iron Dust Core, 1916; Permalloy Dust Core, 1927.



*Shreeve Repeater:
1912.*

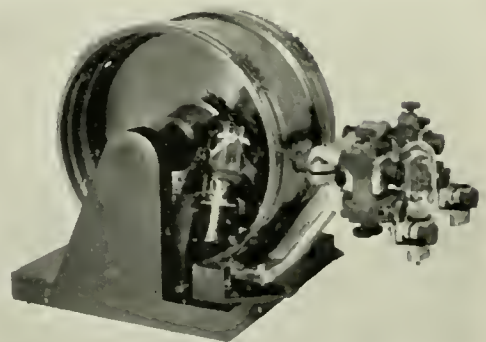


Grace Cable Terminal: 1903.



*Operating Exhibit Dem-
onstrating Permeability.*

FIGURE 9



*Unit of Call Announcer Apparatus:
1929.*

FIGURE 10

CENTRAL OFFICE APPARATUS

The development of central office apparatus occupies the greater part of two single cases. In these are shown exhibits of the earliest and latest plugs, jacks, keys, signals, relays, lamps, lamp caps, cord weights, resistances, message registers, and switchboard clocks. The plugs and jacks begin with code number 1 in each case and continue by type to the latest standard designs. Prior to the present use of code numbers, parts of central office apparatus, like subscriber sets, were known by the name of the designer or the locality where first used. For examples, we have the Williams', Gilliland, Chicago, Detroit, Philadelphia, Liverpool, Antwerp plugs and Scribner, Thayer, Philadelphia, Central Avenue Union, Detroit jacks, a McDaniel's switch and others. Most of these however, were later assigned code numbers. Signals and relays begin with exhibits prior to the time code numbers were assigned. Two developments of train dispatching selectors are also shown.

An interesting exhibit in this case is a unit of the call announcer of 1929, shown in Figure 10. This equipment in a metropolitan office converts the dial impulses into spoken numbers, with or without a party line letter, of a called subscriber in a suburban district. These spoken numbers are heard by the operator in the outlying manual central office. There may be seen the exciting lamp, lens, sound film, on each edge of the continuously revolving drum, and the photoelectric cell. This is a standard arrangement for sound on film reproduction. Each edge of the several revolving drums in the complete central office equipment contains four sections of sound film of a digit or letter. The various dialed numbers or letters through circuit combinations control the proper sequence of the current from the photoelectric cell (amplified) to pass out on the line to the distant operator.

W. C. F. FARNELL

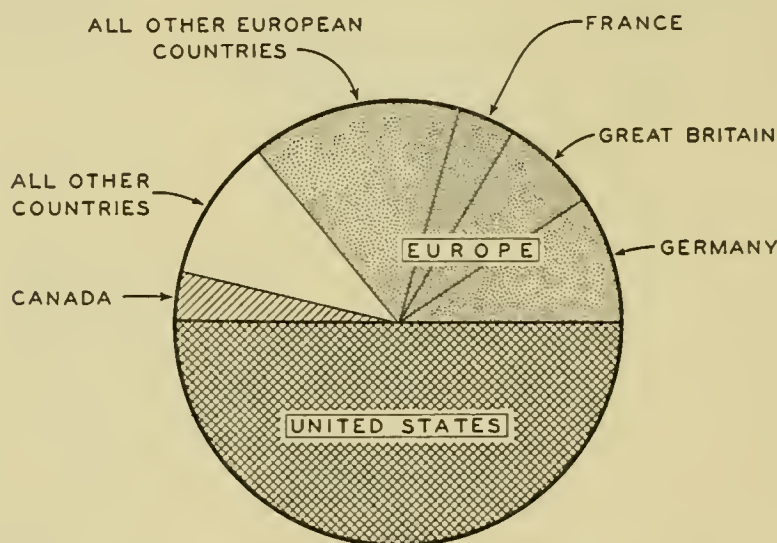
(To be concluded)

The World's Telephone Statistics

January 1, 1935

THERE were 33,539,890 telephones in the world on January 1, 1935, or approximately the same number as were in service just prior to the world-wide business depression which began in 1929. The latest survey of the world's telephone facilities, undertaken by the Chief Statistician of the

DISTRIBUTION OF THE WORLD'S TELEPHONES
January 1, 1935



American Telephone and Telegraph Company, was published recently as a pamphlet entitled "Telephone and Telegraph Statistics of the World, January 1, 1935," from which the tables and charts referred to in the following paragraphs have been taken.

COMPARATIVE TELEPHONE DEVELOPMENT BY COUNTRIES

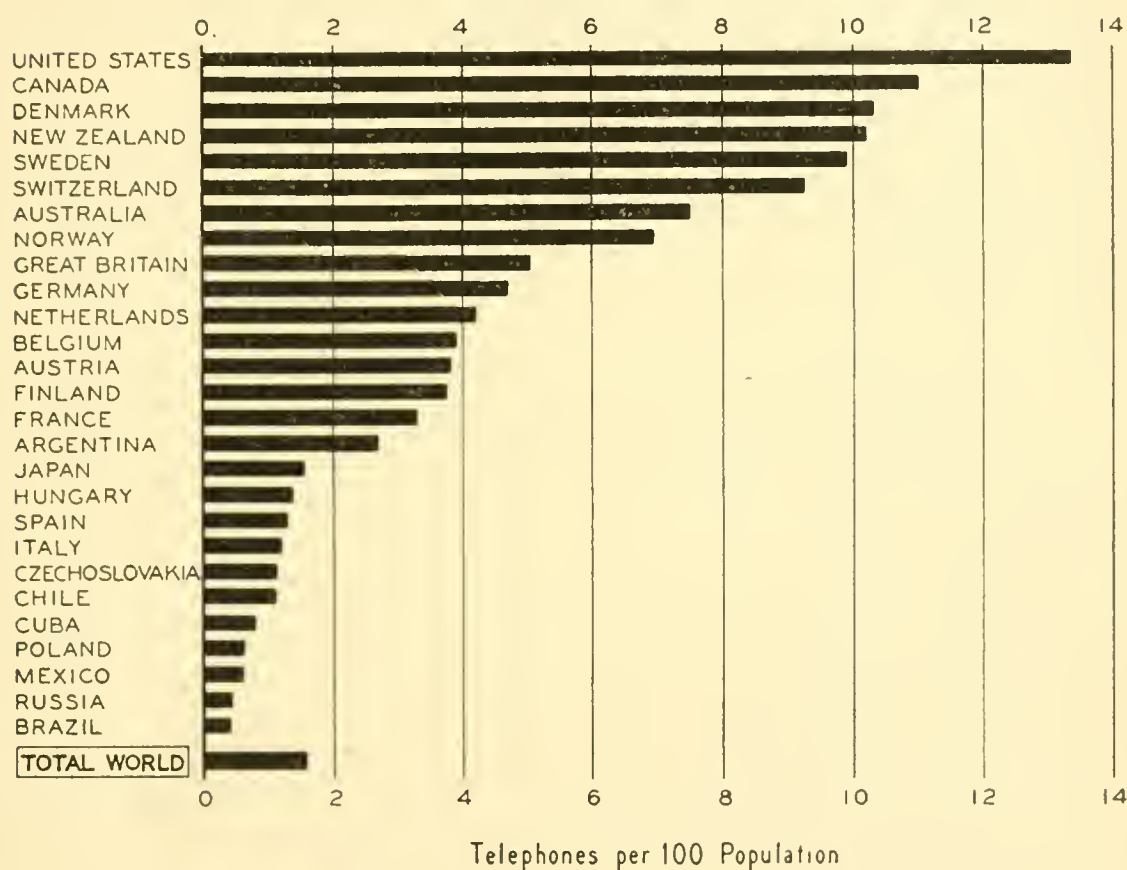
On January 1, 1935, there were 16,868,955 telephones in the United States, representing slightly more than one-half of

THE WORLD'S TELEPHONE STATISTICS

the total number of instruments in the world on that date. A more significant measure of the comparative extent of telephone facilities, however, is furnished by the number of telephones in relation to the population served, as shown in the table "Telephone Development of the World, by Countries" and its accompanying chart "Telephones per 100 Population." As in previous years, the United States exceeds all other coun-

TELEPHONES PER 100 POPULATION

January 1, 1935



tries in terms of this measure of telephone development, having 13.36 telephones for each 100 of its population, or over six times the corresponding telephone development of Europe. Canada continues in second position, with 11.00, followed by Denmark with 10.31 and New Zealand with 10.20 telephones per 100 population. In fact, these four countries are the only ones having more than one telephone for every ten inhabitants.

TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES
January 1, 1935

Countries	Number of Telephones			Percent of Total World	Telephones Per 100 Population
	Government Systems	Private Companies	Total		
NORTH AMERICA:					
United States.....	—	16,868,955	16,868,955	50.29%	13.36
Canada.....	190,602	1,003,127	1,193,729	3.56%	11.00
Central America.....	11,748	13,921	25,669	.08%	0.37
Mexico.....	1,337	107,315	108,652	.32%	0.62
West Indies:					
Cuba.....	500	32,494	32,994	.10%	0.79
Puerto Rico.....	537	11,529	12,066	.04%	0.72
Other W. I. Places.....	7,594	14,800	22,394	.07%	0.33
Other No. Am. Places.....	—	11,111	11,111	.03%	3.03
Total.....	212,318	18,063,252	18,275,570	54.49%	10.47
EUROPE:					
Austria.....	258,748	—	258,748	.77%	3.82
Belgium**.....	323,423	—	323,423	.96%	3.91
Bulgaria.....	20,646	—	20,646	.06%	0.34
Czechoslovakia.....	150,245	21,401	171,646	.51%	1.13
Denmark#.....	16,401	361,164	377,565	1.13%	10.31
Finland.....	2,369	138,698	141,067	.42%	3.75
France.....	1,399,869	—	1,399,869	4.17%	3.30
Germany#.....	3,134,103	—	3,134,103	9.34%	4.69
Great Britain and No. Ireland.....	2,366,311	—	2,366,311	7.06%	5.06
Greece.....	—	26,712	26,712	.08%	0.40
Hungary.....	121,067	735	121,802	.36%	1.37
Irish Free State#.....	34,799	—	34,799	.11%	1.16
Italy.....	—	516,075	516,075	1.54%	1.19
Jugo-Slavia.....	47,234	2,612	49,846	.15%	0.34
Latvia#.....	65,345	—	65,345	.20%	3.35
Netherlands.....	352,741	—	352,741	1.05%	4.20
Norway*.....	121,231	78,453	199,684	.60%	6.96
Poland.....	118,904	92,430	211,334	.63%	0.63
Portugal.....	10,833	38,633	49,466	.15%	0.70
Roumania.....	—	56,797	56,797	.17%	0.30
Russia†.....	739,381	—	739,381	2.20%	0.43
Spain.....	—	312,719	312,719	.93%	1.28
Sweden.....	615,554	1,393	616,947	1.84%	9.90
Switzerland.....	383,289	—	383,289	1.14%	9.25
Other Places in Europe.....	85,153	13,290	98,443	.29%	1.29
Total.....	10,367,646	1,661,112	12,028,758	35.86%	2.13

SOUTH AMERICA:

Argentina.....	—	322,873	322,873	.96%	2.69
Bolivia.....	—	2,218	2,218	.01%	0.07
Brazil.....	1,924	190,742	192,666	.57%	0.41
Chile.....	—	50,360	50,360	.15%	1.12
Colombia.....	7,407	25,377	32,784	.10%	0.34
Ecuador.....	3,121	3,250	6,371	.02%	0.25
Paraguay.....	—	2,996	2,996	.01%	0.33
Peru.....	—	20,985	20,985	.06%	0.32
Uruguay.....	19,651	12,532	32,183	.09%	1.60
Venezuela.....	600	18,685	19,285	.06%	0.58
Other So. Am. Places.....	2,803	—	2,803	.01%	0.52
Total.....	35,506	650,018	685,524	2.04%	0.75

ASIA:

British India#.....	24,328	40,120	64,448	.19%	0.02
China.....	70,000	94,000	164,000	.49%	0.04
Japan#.....	1,068,244	—	1,068,244	3.19%	1.56
Other Places in Asia.....	141,106	66,593	207,699	.62%	0.13
Total.....	1,303,678	200,713	1,504,391	4.49%	0.14

AFRICA:

Egypt.....	49,765	—	49,765	.15%	0.23
Union of South Africa#.....	140,349	—	140,349	.42%	1.64
Other Places in Africa.....	97,750	1,970	99,720	.30%	0.09
Total.....	287,864	1,970	289,834	.87%	0.20

OCEANIA:

Australia*.....	501,402	—	501,402	1.49%	7.51
Dutch East Indies.....	37,407	3,641	41,048	.12%	0.06
Hawaii.....	—	23,857	23,857	.07%	6.36
New Zealand#.....	159,170	—	159,170	.48%	10.20
Philippine Islands.....	6,000	20,358	26,358	.08%	0.19
Other Places in Oceania.....	3,700	278	3,978	.01%	0.17
Total.....	707,679	48,134	755,813	2.25%	0.83
TOTAL WORLD.....	12,914,691	20,625,199	33,539,890§	100.00%	1.58

* June 30, 1934.

** February 28, 1935.

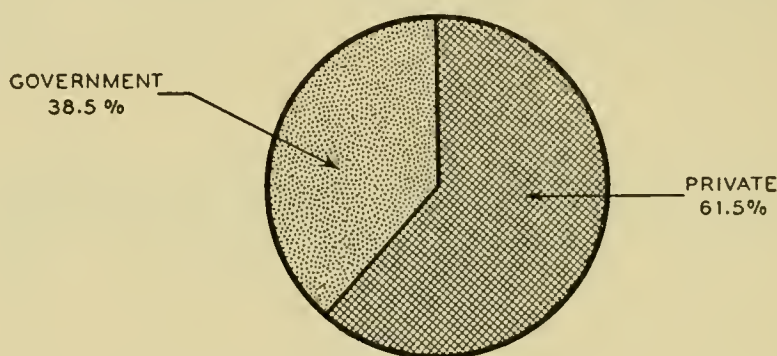
March 31, 1935.

† U.S.S.R., including Siberia and Associated Republics.

§ Includes approximately 15,560,000 automatic or "Dial" telephones, of which about 45% are in the United States.

The major European countries rank lower in relative telephone development; thus, Great Britain with 5.06 telephones per 100 population ranks tenth among the countries of the world. Germany, with a total of 3,134,103 telephones, has more telephones than any other country except the United States, but ranks only eleventh in relative telephone development with 4.69 telephones per 100 population, while France, with 3.30, ranks seventeenth. Japan has 1,068,244 telephones and ranks twenty-first in telephone development (1.56). In South America, Argentina leads in telephone development, with 322,873 telephones, but still has only 2.69 telephones for every 100 of its people.

OWNERSHIP OF THE WORLD'S TELEPHONES
January 1, 1935



More than 61 per cent of the world's telephones are operated by privately owned systems and private ownership tends to predominate in the countries with the highest telephone development. In the United States, the best developed country in the world in point of telephone facilities by a substantial margin, the service is wholly privately operated. Canada, with 84 per cent of the telephones under private operation, is second in telephone development. In Denmark, the world's third highest ranking country in respect of telephone development, 96 per cent of the telephones are owned and operated by private companies. On the other hand, Great Britain, Germany, and France, where all telephone service is operated by

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES

January 1, 1935

Country	Service Operated by (See Note)	Number of Telephones		Telephones per 100 Population	
		In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population	In Communities of 50,000 Population and Over	In Communities of less than 50,000 Population
Australia*	G.	293,477	207,925	9.07	6.04
Austria	G.	197,134	61,614	8.97	1.35
Belgium**	G.	227,133	96,290	6.43	2.03
Canada	P. G.	647,481	546,248	18.99	7.34
Czechoslovakia	P. G.	87,092	84,553	5.06	0.63
Denmark	P.	196,404	183,596	19.07	6.95
Finland	P.	54,141	86,926	11.00	2.66
France	G.	755,526	644,343	8.51	1.92
Germany†	G.	1,897,458	1,056,156	7.12	2.69
Great Britain and No. Ireland#	G.	1,740,600	676,000	6.59	3.33
Hungary	G.	92,679	29,123	4.53	0.43
Japan#	G.	699,811	368,433	3.51	0.76
Netherlands	G.	229,881	122,860	6.71	2.47
New Zealand#	G.	63,730	95,440	11.10	9.68
Norway*	P. G.	78,421	121,263	19.36	4.92
Poland	P. G.	122,452	88,882	2.46	0.31
Spain	P.	193,841	118,878	3.80	0.61
Sweden	G.	240,801	376,146	23.13	7.24
Switzerland	G.	173,861	209,428	19.76	6.41
Union of South Africa	G.	82,487	57,852	7.25	0.78
United States	P.	9,608,965	7,259,990	18.91	9.62

Note: P. indicates that the telephone service is wholly or predominantly operated by private companies, G. wholly or predominantly by the Government, and P. G. by both private companies and the Government. See first table.

* June 30, 1934.

† March 31, 1934.

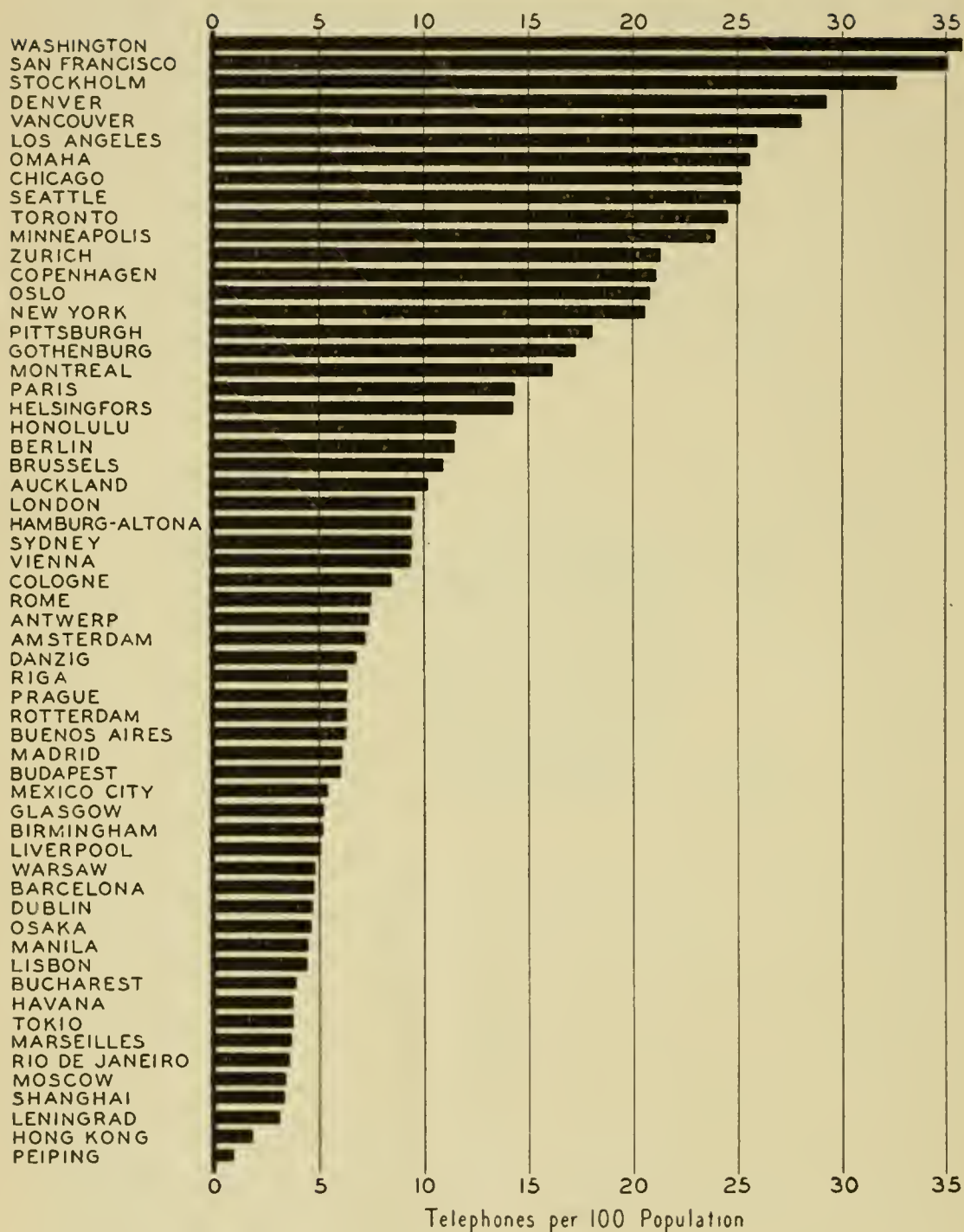
** February 28, 1935.

March 31, 1935.

BELL TELEPHONE QUARTERLY

TELEPHONES PER 100 POPULATION OF LARGE CITIES

January 1, 1935



government agencies, have a telephone development only a fourth to a third as high as that in the United States.

THE WORLD'S TELEPHONE STATISTICS

TELEPHONES IN LARGE CITIES

At the beginning of 1935, the largest 54 cities in the United States had more telephones (7,570,610) than France, Germany, and Great Britain combined, despite the fact that the aggregate population of these three countries is many times that of the 54 American cities. Among the large cities of the world, Washington, D. C., leads in relative telephone development, with 35.80 telephones per 100 population, closely followed by San Francisco, with 35.08. Stockholm, Sweden, ranked third with 32.64 and far exceeded all other European cities. As a matter of fact, the next highest ranking city in Europe was Berne, Switzerland, with 21.92 telephones per 100 population—a development exceeded by as many as 33 cities in the United States. London, a larger city than New York, had 891,725 telephones compared with New York's 1,493,374 telephones, and a relative development of 9.59 compared with New York's 20.61 telephones per 100 population. Berlin, somewhat larger than Chicago, had 488,244 telephones and a relative development of 11.49, while Chicago had 824,293 telephones or 25.21 per 100 population. Paris had 416,870 telephones and a development of 14.35, or about one-half the development of Los Angeles (25.95), which had 341,221 telephones.

TELEPHONES IN LARGE AND SMALL COMMUNITIES

The general penetration of telephone service in communities of all sizes in the United States may be seen from the following tabulation:

	Telephones per 100 Population
Communities with over 1,000,000 population.....	20.38
Communities with 500,000 to 1,000,000 population.....	20.27
Communities with 200,000 to 500,000 population.....	17.78
Communities with 50,000 to 200,000 population.....	16.54
Communities with less than 50,000 population.....	9.62

TELEPHONE DEVELOPMENT OF LARGE CITIES

January 1, 1935

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINA:			
Buenos Aires.....	3,000,000	188,528	6.28
AUSTRALIA:			
Adelaide.....	314,000	28,949	9.22
Brisbane.....	305,000	26,707	8.76
Melbourne.....	1,000,000	103,137	10.31
Sydney.....	1,249,000	117,759	9.43
AUSTRIA:			
Graz.....	153,000	10,784	7.05
Vienna.....	1,875,000	175,947	9.38
BELGIUM: **			
Antwerp.....	530,000	39,228	7.40
Brussels.....	965,000	105,654	10.95
Liege.....	424,000	23,695	5.59
BRAZIL:			
Rio de Janeiro.....	1,800,000	64,046	3.56
CANADA:			
Montreal.....	1,016,700	164,594	16.19
Ottawa.....	188,000	35,441	18.85
Toronto.....	766,300	188,287	24.57
Vancouver.....	187,500	52,549	28.03
CHINA:			
Canton.....	1,060,000	8,056	0.76
Hong Kong.....	850,000	14,845	1.75
Peiping.....	1,540,000	12,948	0.84
Shanghai ††.....	1,650,000	54,861	3.32
CUBA:			
Havana.....	700,000	25,899	3.70
CZECHOSLOVAKIA:			
Prague.....	913,000	57,725	6.32
DANZIG:			
Free City of Danzig.....	265,000	17,964	6.78
DENMARK:			
Copenhagen.....	820,000	173,372	21.14
FINLAND:			
Helsingfors.....	270,000	38,653	14.32
FRANCE:			
Bordeaux.....	268,000	20,348	7.59
Lille.....	202,000	17,346	8.59
Lyons.....	670,000	35,317	5.27
Marseilles.....	930,000	34,165	3.67
Paris.....	2,905,000	416,870	14.35
GERMANY:‡			
Berlin.....	4,250,000	488,244	11.49
Breslau.....	630,000	42,185	6.70
Cologne.....	765,000	64,935	8.49
Dresden.....	735,000	60,899	8.29
Dortmund.....	585,000	23,958	4.10
Essen.....	665,000	30,254	4.55
Frankfort-on-Main.....	655,000	61,968	9.46
Hamburg-Altona.....	1,650,000	155,826	9.44
Leipzig.....	775,000	65,038	8.39
Munich.....	745,000	79,219	10.63
GREAT BRITAIN AND NO. IRELAND:‡			
Belfast.....	415,000	19,280	4.65
Birmingham.....	1,210,000	62,147	5.14
Bristol.....	417,000	22,711	5.45
Edinburgh.....	444,000	34,565	7.78
Glasgow.....	1,195,000	61,747	5.17
Leeds.....	514,000	25,922	5.04
Liverpool.....	1,200,000	60,131	5.01
London.....	9,300,000	891,725	9.59
Manchester.....	1,103,000	67,336	6.10
Newcastle.....	471,000	20,558	4.36
Sheffield.....	520,000	21,202	4.08
HAWAII:			
Honolulu.....	138,000	15,942	11.55
HUNGARY:			
Budapest.....	1,360,000	81,886	6.02
Szeged.....	138,000	2,100	1.52
IRISH FREE STATE:‡			
Dublin.....	429,000	19,920	4.64

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)

January 1, 1935

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ITALY:			
Milan.....	1,065,000	88,701	8.33
Naples.....	880,000	27,098	3.08
Rome.....	1,150,000	86,393	7.51
JAPAN:†			
Kobe.....	854,000	34,700	4.06
Kyoto.....	1,053,000	42,408	4.03
Nagoya.....	1,018,000	34,846	3.42
Osaka.....	2,723,000	124,883	4.59
Tokio.....	5,663,000	209,605	3.70
LATVIA:†			
Riga.....	385,000	24,437	6.35
MEXICO:			
Mexico City.....	1,150,000	61,969	5.39
NETHERLANDS:			
Amsterdam.....	782,000	56,468	7.22
Haarlem.....	162,000	12,775	7.89
Rotterdam.....	616,000	38,808	6.30
The Hague.....	518,000	48,939	9.45
NEW ZEALAND:†			
Auckland.....	218,000	22,236	10.20
NORWAY:*			
Oslo.....	250,000	52,198	20.88
PHILIPPINE ISLANDS:			
Manila.....	394,000	17,328	4.40
POLAND:			
Lodz.....	900,000	14,356	1.60
Warsaw.....	1,260,000	59,842	4.75
PORTUGAL:			
Lisbon.....	651,000	28,470	4.37
ROUMANIA:			
Bucharest.....	640,000	24,718	3.86
RUSSIA:			
Leningrad.....	3,000,000	91,023	3.03
Moscow.....	4,000,000	134,440	3.36
SPAIN:			
Barcelona.....	1,080,000	51,014	4.72
Madrid.....	1,000,000	61,017	6.10
SWEDEN:			
Gothenburg.....	255,000	44,228	17.32
Malmö.....	139,000	21,591	15.56
Stockholm.....	441,000	144,011	32.64
SWITZERLAND:			
Basel.....	151,000	32,441	21.48
Berne.....	114,000	24,992	21.92
Geneva.....	147,000	27,235	18.53
Zurich.....	268,000	57,330	21.39
UNITED STATES: (See Note)			
New York.....	7,247,000	1,493,374	20.61
Chicago.....	3,270,000	824,293	25.21
Los Angeles.....	1,315,000	341,221	25.95
Pittsburgh.....	1,015,900	183,761	18.09
Total 10 cities over 1,000,000 Population.....	21,777,600	4,437,758	20.38
Milwaukee.....	763,200	135,963	17.81
San Francisco.....	690,000	242,026	35.08
Washington.....	528,000	189,017	35.80
Minneapolis.....	505,000	121,123	23.98
Total 10 cities with 500,000 to 1,000,000 Population..	6,515,300	1,320,692	20.27
Seattle.....	417,200	105,087	25.19
Denver.....	300,000	87,755	29.25
Omaha.....	238,600	61,186	25.64
Hartford.....	237,300	53,224	22.43
Total 34 cities with 200,000 to 500,000 Population....	10,191,900	1,812,160	17.78
Total 54 cities with more than 200,000 Population..	38,484,800	7,570,610	19.67

NOTE: There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representative cities within each of such groups.

* June 30, 1934.

** February 28, 1935.

March 31, 1935.

†† International Settlement and French Concession.

The last figure is particularly significant in view of the fact that it represents a telephone development for the more sparsely settled areas of the United States which not alone surpasses the total telephone development of all but a few other countries, but even exceeds the urban telephone development of all but seven foreign countries. This situation is a reflection of the fact that in foreign countries telephone facilities tend to be concentrated in the larger metropolitan centers, with much more limited service being provided in the smaller communities and rural areas. Thus, the city of London had over 36 per cent of all the telephones in Great Britain and Northern Ireland, while communities of less than 50,000 inhabitants in Great Britain had only 3.33 telephones per 100 population, or approximately one-third of the corresponding development in the United States. Similarly, almost 30 per cent of all French telephones were in Paris, the development of communities of less than 50,000 inhabitants in France being only one-fifth as high as that of corresponding communities in the United States. New York and Chicago combined, on the other hand, had less than 14 per cent of all telephones in the United States.

K. FICK

Notes On Recent Occurrences

FURTHER REDUCTIONS IN RATES FOR OVERSEAS TELEPHONE SERVICE

ON July 1 reduced rates became effective for telephone calls from all places in the United States to most foreign countries. Reductions apply to nearly 50 of the 68 countries which may be reached from Bell System telephones. Negotiations are under way looking to reductions on charges for overseas calls to other countries. The reductions apply to day rates and to night rates, and introduce a reduced rate on Sunday. Reductions were also made in rates from the United States to Cuba, which is reached by deep sea cable.

Under the new schedule, three-minute calls from the eastern seaboard cities to Paris and London are reduced from \$30 to \$21 in the day time, and the Sunday and night charge is \$15. This is a reduction, on three-minute calls to countries in Europe, of \$9 on week days, \$6 at night, and \$15 on Sundays. Three-minute calls from Pacific Coast cities to the Territory of Hawaii are reduced from \$21 to \$15 on week days, while the new Sunday rate is \$10.50. Similar calls to the Philippines are reduced from \$30 to \$21 on week days, with a Sunday rate of \$15. Three-minute calls to the countries of Argentina, Brazil, Chile, Paraguay, Peru and Uruguay in South America are reduced \$9 on week days and \$15 on Sundays, while calls to Colombia are reduced \$9 on week days and \$13.50 on Sundays. Similar calls to the Central American Republics of Costa Rica, Guatemala, Honduras, Nicaragua, and Panama are reduced \$9 on week days and \$12 on Sundays. Calls to Puerto Rico and the Dominican Republic are reduced \$6 on week days and \$9 on Sundays. Rates for conversations extending beyond three minutes are similarly reduced. To Cuba,

BELL TELEPHONE QUARTERLY

three-minute station-to-station calls are reduced by \$1.50 and person-to-person calls correspondingly; also, the schedule introduces reduced night and Sunday rates.

Since the American Telephone and Telegraph Company inaugurated radio-telephone service to Europe in 1927, there have been two previous substantial reductions in charges for the service. When the service opened, a three-minute conversation between New York and London cost \$75. In 1928 the rate was reduced to \$45, and in 1930 the Company made a further reduction to \$30. The present reduction brings it to \$21.

The following table compares the former and the new day rates for a three-minute conversation:

	Former Rate	New Week-day	New Sunday
New York-London	\$30	\$21	\$15
New York-Buenos Aires	30	21	15
New York-Rio de Janeiro	30	21	15
New York-Lima	30	21	15
New York-Paris	30	21	15
New York-Berlin	33	24	18
New York-Santiago, Chile	33	24	18
New York-Panama City	21	12	9
New York-Guatemala	21	12	9
New York-San Juan	18	12	9
Seattle-Honolulu	21	15	10.50
Los Angeles-Manila	30	21	15.00
Miami-Bogota	21	12	7.50
New York-Ciudad Trujillo	18	12	9

The night rates to London, Paris and Berlin are the same as the Sunday rates under the new schedule.

BELL SYSTEM OPENS SERVICE TO EL SALVADOR

TELEPHONE service with El Salvador, Central America, was opened on June 10 with an exchange of greetings between Secretary of State Cordell Hull at Washington and Dr. Miguel A. Araujo, Minister of Foreign Relations for El

NOTES ON RECENT OCCURRENCES

Salvador at San Salvador. Others taking part in the inaugural conversations included Don Hector D. Castro, Salvadoran Minister to the United States, at Washington, and Frank P. Corrigan, American Minister to El Salvador.

With the extension to El Salvador, service from Bell and Bell-connecting telephones is now available to all of the Central American Republics. El Salvador is the most densely populated country in the western hemisphere, with a population estimated at 1,670,000 in an area of 13,000 square miles.

The cost of a three-minute conversation between New York and San Salvador is \$12.00, with \$4.00 for each additional minute. Connection is established over a short wave radio telephone circuit between A. T. & T. Company stations at Miami, Fla., and a Salvadoran radio-telephone station located at San Salvador.

BELL SYSTEM OFFICIALS RECEIVE HONORARY DEGREES

WORCESTER Polytechnic Institute conferred the honorary degree of Doctor of Engineering on Bancroft Gherardi, Vice President and Chief Engineer of the American Telephone and Telegraph Company, at its Commencement exercises on June 12. Dr. Gherardi delivered the Commencement Address to the graduating class.

At its Commencement exercises on June 18 Harvard University conferred the honorary degree of Doctor of Science on Frank B. Jewett, Vice President of the American Telephone and Telegraph Company and President of the Bell Telephone Laboratories.

Other members of the Laboratories who received honorary doctorates were: O. E. Buckley, Doctor of Science, from Grinnell College; J. R. Carson, Doctor of Science, from Brooklyn Polytechnic Institute; and M. J. Kelly, Doctor of Engineering, from the School of Mines and Metallurgy of the University of Missouri.

BELL TELEPHONE QUARTERLY



V. XV

OCTOBER, 1936

NO. 4

THE SOCIAL IMPLICATIONS OF SCIENTIFIC
RESEARCH IN ELECTRICAL COMMUNICATION

MORE TELEPHONE BUILDINGS

THE DEVELOPMENT OF DINING SERVICE AND
OTHER QUARTERS FOR BELL SYSTEM WOMEN

THE BELL SYSTEM HISTORICAL MUSEUM

BELL TELEPHONE QUARTERLY

*A Medium of Suggestion
and a Record of Progress*

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VOL. XV

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The Social Implications of Scientific Research in Electrical Communication*

IT HAS been suggested by those responsible for the program of the Harvard Tercentenary that as a conclusion to the discussions in fundamental science which have marked your deliberations for the past two weeks, it would be appropriate to consider some of the practical results attendant upon our attempts to utilize science in our industrial and social affairs. They have suggested further that some discussion of the efficacy of introducing the powerful tools of the research laboratory into industry might be in order and that recent advances in telephony would supply good illustrative material.

In accepting their invitation I must express my appreciation of the honor they have conferred on the scientific men of the electrical communication industry and on me in designating me as their spokesman.

By suggesting this sort of termination for the discussions, I assume that the Tercentenary Committee had in mind not only practical values of an economic kind but likewise practical values of a social nature. After all, unless we are clear as to the existence of social values and are prepared to appraise them honestly and be guided by the results of our appraisal, the dollars and cents values of our work are more likely than not to turn to ashes in our hands.

The purpose which the Tercentenary Committee had in mind could be accomplished by scrutiny of examples from almost any of the great modern industries which have developed on the foundation facts, techniques and methods of science.

* Excerpts from a lecture given in Sanders Theater, Cambridge, Mass., before the Harvard Tercentenary Conference of Arts and Sciences, by Dr. Frank B. Jewett, Vice President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories.

None of them, however, I think more completely exemplifies the present and prospective economic and social values of practical applications of science than does that part of electrical communication which we designate as telephony. Nor is there any other in which, so far as I am aware, the fundamental principles of the scientific method have been extended so greatly to control accurately, uniformly and continuously the operation of a vast human and material mechanism. This control is imperative if the service is to have that degree of reliability demanded by the requirements of a social and business society organized to a large extent on the assumption that satisfactory telephone service is always instantly available.

FACTORS IN THE DEVELOPMENT OF TELEPHONY

Time does not permit any discussion in detail of how this has been made possible nor is there any necessity here of such discussion. All that need be mentioned is that among the principal factors have been a fortunate development of fundamental science itself in regions applicable to electrical communication; in an early appreciation of the power for advancement inherent in the slow but certain results of rigorously controlled experimentation, and in the almost equally early realization that in any community or region telephony must be a single service but one in which the physical means and human methods of operation are so chosen as to act harmoniously with the means and methods employed everywhere else.

Added to these and furnishing a rigid yardstick by which every new proposal must be measured is the fact that time is an all important factor. On its purely physical side, two-way telephony to be of value must involve essentially instantaneous transmission of intelligence between terminals; otherwise normal conversation would not be possible. Nothing which introduces substantial deviation from this requirement is admissible no matter how attractive it may be otherwise.

Further, every telephone circuit, whether it be between

THE SOCIAL IMPLICATIONS OF SCIENTIFIC RESEARCH

terminals in adjacent rooms or between those separated by half or more of the circumference of the earth, must be a cleared channel established with minimum delay on demand in order that the correspondents be brought immediately vis-a-vis. On the operational side, therefore, time is also an essential factor and while it is inherently impossible to establish instantly any connection that may be asked for, everything that is reasonably possible is demanded to the end that every calling subscriber is served immediately on request.

In no other social service I am familiar with does the element of time play such an imperious controlling part.

A SERVICE ROOTED IN SCIENCE

While there are still vast areas both in the science and operational regions where we know that great progress is still possible, we have already gone sufficiently far in our development of the art to have telephone service begin to take on the form of complete universality. With it have come marked changes in our methods of social and business intercourse, in our economic and political machinery and in the problems presented to our courts for adjudication. All of these things and their corresponding elements in other industries have their roots in science and whether or not we are conscious of it, it is the possibilities and limitations of this science root structure which in the end will largely determine the resulting form of our society.

So far have we gone already in perfecting the adaptation of science to the art of telephony that most of us when we use the telephone are not even cognizant, except vaguely perhaps, of the fact that our ability to talk freely wherever and whenever we wish is the result of an infinite amount of work by the men in the laboratory. We are not conscious of the fact that these men have been and are being confronted daily with myriads of problems—all obstacles of one sort or another. Some they conquer and eliminate—some they learn to control and utilize. In the end, they have produced a gossamer web of filaments

which, in spite of being beset with a multitude of enemies, they have succeeded in protecting and making available for its one and only function—that of enabling us to convey intelligible speech sounds to distant places. So effectively has this work been done that in many instances the men and women who install and operate the telephone plant are themselves unaware of the things done to make it smoothly operative.

THE UNDERLYING PROBLEM OF EDUCATION

This taking-for-granted attitude on the part of the many is common in every technical application of science to our daily usage. From it and from its corollary—action of a social, political or economic character with little or no understanding of the underlying and controlling forces—come most of our problems of proper social control of these new things. One of the biggest, if not the biggest problem ahead of us, is the educational problem of teaching a vast population, which is becoming more and more dependent on the things of applied science, enough of their inherent possibilities and limitations so that they can operate the social controls without danger of wrecking the machinery.

As one infinitesimal contribution to this educational problem and simply by way of illustrating in the field of telephony a few of the problems research men are solving every day in a multitude of industries, I shall give you a few demonstrations of things not normally observable when we use the telephone but which constitute some of the hidden factors I have mentioned. I shall begin by setting up a couple of telephone connections such as are regularly provided in the public service. This is merely to refresh your minds as to the results you obtain when you use the telephone. Except for the fact that you will hear through a loud speaking telephone, which for best results requires a transmission circuit slightly different from that ordinarily employed with a hand telephone, the result of one connection at least will be commonplace to all of you who

THE SOCIAL IMPLICATIONS OF SCIENTIFIC RESEARCH

have occasion to employ the long distance telephone. The other, which will be a long distance conference call, may be strange to most of you although it is coming into somewhat general use in business operations. Then we will pick these or a similar circuit apart a bit and show you a few of the many hidden forces which the research man has either had to overcome or develop and control in order to give the operating people and you long and complicated circuits which apparently operate like short and simple ones. I shall endeavor also to show you a few of the odd things which our knowledge of science has enabled us to utilize in giving types of telephone service which would otherwise be impossible.

Finally, with the collaboration of Mr. Dudley, you will have a glimpse through the crack that the research man has made in the wall surrounding a hitherto undeveloped field in the realm of communication possibilities.

THE SOCIAL IMPLICATIONS OF SCIENTIFIC RESEARCH

All of this is designed merely to give a springboard from which to project what seem to me a few plausible conclusions as to the social implications of scientific research in electrical communication and inferentially in many other fields as well.

Before going on to the demonstrations, it may be of interest to note briefly by analogy and otherwise what our present telephone facilities here in the United States really provide and some of the grosser effects which would result from their substantial annihilation.

Imagine direct railroad tracks from every city, village and hamlet to every other city, village and hamlet. Imagine a train on every track, steam up, ready to start at a moment's notice to any destination. Imagine the track facilities so ample that, no matter how numerous the trains, there are no delays either in going or returning. Imagine, further, that the trains move with incredible speed which in many cases is virtually that of light. Here we have in substance the achievement of

modern telephony when we realize that the cargo on the trains is human thought as conveyed by the spoken word. Recalling the words which Emerson wrote years ago at the completion of the first Atlantic cable—

“The lightning has run masterless too long;
He must to school and learn his verb and noun
And teach his nimbleness to earn his wage,
Spelling with guided tongue man’s messages.”—

how uncommonly prophetic these have proved! How well the lightning has learned his lesson.

Without the telephone, modern tall buildings and the correlated extreme density of populations in many of our urban developments would be either impossible or more encumbrances than aids to life and business. To carry by messenger the communications which enter and leave a tall office building by telephone during the rush hours, would block corridors and elevators and produce unprecedented traffic jams in the streets outside. For every person who walks along a busy city street, the telephone enables a much larger number to project their thoughts and personalities along the circuits below the street. Usually the telephone delivers a message and brings an answer in less than the time it would take to transcribe it for a messenger.

Merely to mention the number of calls completed each year over our American telephone system takes us at once into astronomical magnitudes. For the past year, the number was twenty-five billion. While the major portion of these were local calls, a vast number were long distance and, with added facilities and the prospect that through further research, costs can be lowered, there is every reason to believe that the time is not far distant when the number will be increased many fold.

When one attempts either by word of mouth or by demonstration to explain the recent problems of telephony and how they are being overcome, he finds that he has a uniquely difficult piece of work in hand. He must discourse upon a struc-

ture, the long telephone line, which neither he nor anyone in his audience has ever seen in its entirety, and he must, unless addressing a group of his own kind, put into words a host of concepts which find their proper expression only in mathematical symbols and processes or in the special language of the physicist. If I could transport you rapidly out across the continent three thousand miles or so, thus enabling you in the course of a few minutes to visualize what a complex thing a modern long distance telephone line actually is, I might hope to convey to you a superficial conception of the elaborate and fragile thing I am talking about. Only thus would many of you sense how remarkable it is that this frail far-flung structure should be endowed with surprising electrical stability and immunity to meteorological and man-made disturbances.

A BIRD'S-EYE VIEW OF A LONG LINE

Were we to make such a flight, what actually would we find over and above the pairs of wires which every one recognizes as among the constituents of all telephone circuits—the wires which in one form, the open or exposed form, de Chavannes depicted in his painting in the Boston Public Library? We would find as a matter of fact, that these pairs of open wires represent a type of construction which is now rather in the minority even for long distance telephony. For reasons of better protection and stability, particularly in regard to electrical leakage, the wires composing even very long circuits are now frequently packed tightly together and enveloped in an impervious lead sheath to form a cable in which neutral gas, such as nitrogen, is maintained under pressure.

Continuing our imaginary flight, we would encounter on each of the hundreds of pairs of wires within each cable and at absolutely regular intervals varying from about $\frac{5}{8}$ mile to $1\frac{1}{8}$ miles on different circuits, a loading coil—a coil of wire on a special magnetic core whose function is to assist the speech currents, as they travel, to overcome the large attenuating

effect of the electrostatic capacity of the tightly packed wires. These coils, of which there may be as many as two or three thousand called into play in the handling of a single message, must be identical to a degree characteristic of the watchmaker's precision. Next, there is the repeated and uniform twisting of each pair of wires at its own particular pitch to secure such nicety of balance, both electrostatic and electromagnetic, that not more than a millionth of the power of a telephone circuit will pass over inductively to any neighboring circuit. Then at intervals of fifty miles for certain types of cables, and at shorter intervals—even as low as ten miles on certain newly projected types—we would encounter the thermionic amplifiers which restore the message energy after attenuation by resistance and other forms of dissipation. Closely associated with certain of these amplifiers are the regulators which automatically counteract the effect of changes in conductor resistance induced by changes in temperature. As an illustration of how important the regulators are, they must allow the total amplification of a long circuit to increase between winter and summer by as much as the factor 10^{20} . Then too there are the smaller diurnal variations which it is even more important to compensate for automatically because they are naturally of a very irregular pattern. The emergence of the sun from behind clouds or an icy blast along one section of a toll cable is registered almost immediately by a large alteration in the attenuation of the circuits within it. In case a cable is placed underground, the temperature changes to which it is subjected are of course of smaller amplitude and longer period, but for them too it has been found best to compensate on the automatic pilot wire basis.

In our overland flight we would actually see many other essential telephonic devices which cooperate to insure the steady and uninterrupted operation of the lines, but since our time is limited I must stop with the bolder details of the picture. I hope they will be sufficient to give you at least some visualiza-

tion of what science has enabled the telephone engineer to accomplish. So stable in operation is the telephone plant of today that in spite of the apparently fragile nature of its long lines, which in turn depend upon the uninterrupted functioning of many thousands of delicate electronic devices, it is available every hour of the day, day in and out. Along with growth in reliability despite an ever increasing dependence on delicate structures, has come a marked increase in the amount and scope of facilities as a result of the continually decreasing cost of circuits brought about by research. This combination of enhanced reliability, at cost sufficiently low to permit circuits to be provided in profusion, has made it possible for you to reach a distant party without leaving the telephone and has made operating delays a rarity rather than a commonplace.

To illustrate this point I am going to place one or two long distance calls. Even after thirty odd years' intimate association with telephone development, I still confess to a certain awe at the speed with which the telephone operators are today able to transport one about the country. In a sense, we are about to bring that painting by de Chavannes to life, and because I want you to hear with me how the girls operate the circuits I have arranged that whatever is audible on this telephone will also be reproduced by the loud speakers which you see here on the stage.

* * * * *

[At this point Dr. Jewett talked by long distance telephone with Dr. Robert A. Millikan, in Pasadena, California, and then, over a conference circuit, talked with telephone officials in New York, Atlanta, Chicago, St. Louis and San Francisco.]

* * * * *

So much by way of refreshing your minds on what normal telephone calls are like. I am now going to take a long circuit similar to those we have just used and perform some experiments with it merely to show you a few of the obstacles with

which the research men have had to contend in order to give us our apparently simple circuits.

It won't be practicable to have the circuit here before you because it is actually 1700 miles long and extends in cable from Cambridge to Charlotte, N. C., and back. You will have to take my word for it therefore when I say that it includes approximately 3000 loading coils, 40 equally spaced vacuum tube amplifiers, pilot wire regulators which control their gain to compensate for changes in temperature, and other devices, such as echo suppressors, the purpose of which I will return to in a moment. You will not, however, have to take my word for the curious phenomena which such a circuit exhibits—phenomena which are displayed best in a very long circuit—because with the aid of the loud speakers you will all be able to observe the circuit's performance when normal conditions of operation are disturbed.

THE TELEPHONE LINE AS AN INTEGRATED ENTITY

At the outset let me say a word or two as to a basic characteristic of long speech highways in which they differ fundamentally from other highways. The telephonic highway must respond as a single unit from end to end or not at all. It is a single entity, almost a living organism which, if disturbed at one point, reacts throughout. As a coordinated, balanced and self-contained unit, it is undoubtedly the most extended structure man has thus far built. Not like the highways for rolling stock which may be torn up for considerable sections without interrupting the flow of through traffic, we must consider the telephone line, even though thousands of miles long, as a single integrated entity. This characteristic underlies the demonstrations I have arranged.

Familiarity on your part with the general functioning of the vacuum tube, now indispensable as an amplifier in all forms of electrical communication, I must assume. We will pass on at once to consider the degree of perfection as regards accuracy

and stability to which the device has been brought in the telephone plant. As I mentioned earlier, I have here the terminals of a circuit 1700 miles long which is looped down to Charlotte, N. C., and which contains 40 amplifiers, each supplying an average gain rather greater than ten-fold. This gain is required since at each amplifier the speech current has been attenuated by resistance and other losses to about the value it must have at the receiving terminal. Further transmission without distortionless amplification would so weaken the current as to make it useless. A graph of current along the line would present a saw-tooth appearance—the value on reaching each repeater or amplifier being a minimum and beyond each amplifier being substantially that at the sending end.

Since the speech current passes through each amplifier successively, it receives this ten-fold boost at each so that after having passed the second amplifier the total gain is 10×10 ; at the third, it is $10 \times 10 \times 10$, and the total amplification from end to end of the circuit is 10^{40} , i.e. 10 with 39 naughts after it. Here indeed we are dealing with astronomical magnitudes. In terms of a more familiar physical quantity, this is multiplication about equivalent to taking a single atom of hydrogen, and magnifying it until it fills the entire solar system. Surprising as it is that such amplifications are attainable, it is even more unexpected to find them produced as an everyday affair with so little distortion that the final product at the receiving end is essentially indistinguishable from the original, and so perfectly under control that the overall variation in magnitude is negligible. Just to show that there is no perceptible distortion I will ask Mr. Thompson, one of my assistants, to enter the booth in the corner and speak to you, first directly through the loud speakers and then over the 1700 mile looped circuit.

* * * * *

[At this point Dr. Jewett conducted various demonstrations to show the functions of the repeater, echo suppressor, speech

inverter and other equipment affecting the transmission characteristics of long circuits, which were followed by a demonstration of synthesized speech by Mr. Homer Dudley, of the staff of the Bell Telephone Laboratories.]

* * * * *

These few demonstrations and all that we have told you are but minute examples of the results that have come from organized scientific research in the one field of electrical communication. Most of what we now have or of what we envisage for the future could not have been obtained except through rigorous application of the facts and methods of science in a broad frontal attack such as organized cooperative effort alone can make. It is not too much to expect that a continuation of the method will ultimately result in the substantial destruction of the barrier to conversation wherever and whenever desired which distance has imposed in the past. Since there is even now no physical obstacle of distance, this is simply another way of saying that a continuation of organized research gives promise of providing speech channels so numerous and relatively so cheap that the economic barriers to full usage will be obliterated.

A COMPLETE NERVOUS SYSTEM FOR SOCIETY

When this time comes, society for the first time in its long evolutionary history will through the varied forms of electrical communication have a complete nervous system. In many respects it will present striking similarities to man's nervous system. It cannot help but speed up what Spencer termed superorganic evolution and will in fact make possible a type of political state which could not develop without it.

Time does not permit any elaboration of the effects on society of this obliteration of distance as they influence the action and interaction of our human social atoms. My purpose here today has been served if I have conveyed to you some under-

standing of what scientific research in the communication field has already done and what it seems prepared to do in the future in the way of putting men everywhere in position to act with the same facilities, as regards interchange of ideas, as if they were in one room.

One could spend hours developing in detail the multitude of ways in which the things evolved by organized scientific research in the field of electrical communication have influenced our modes of life. When all is said, however, the broad implications are to be found in the result just mentioned, namely, that through it we have already gone a long way toward providing society with a complete nervous system and have every prospect of finishing the job.

My purpose has been served further if it has given you a better idea of the vast power in coordinated research for solving incredibly intricate problems of a very practical nature and for developing adequate controls over multitudinous conflicting forces in such simple form that they can be operated easily by essentially unskilled people.

What organized scientific research has done and is doing in the field of communication is being repeated in a host of other fields. Everywhere there is growing evidence that the power inherent in the scientific method when applied to the prosaic affairs of everyday life is coming more and more to be understood.

The ever increasing flood of new tools which fundamental and applied science are giving us is obvious. So, too, are the initial results on society of their mass introduction into it. What is not so obvious are the processes by which they will gradually be fitted smoothly into an orderly society built up around them.

The one thing that is quite clear to me is that since these new tools are the direct result of operating a powerful method by skilled people, it is imperative if full social value is to be obtained that the method which produced them be extended

and that men and women be truly trained to apply it—not to produce new things but show us how properly to use them. In this it will not suffice to do what we have so frequently done in the past, feel that we are making progress by giving things awe-inspiring titles which serve merely to cloak shallowness of understanding.

To the extent, however, that we are able to introduce the elements of this proven method of rigidly controlled and co-ordinated experimentation into the stream of our social and political evolution, to that extent will we be able to simplify and expedite our progress.

FRANK B. JEWETT



MORE TELEPHONE BUILDINGS

THE BELL TELEPHONE QUARTERLY for July, 1929, contained an article, "Bell System Buildings—an interpretation," by R. S. Coe.

Enough was said and pictured to show that these modern buildings, planned to provide at reasonable cost for present service needs and for the continuing growth of telephone use, reflect in their character something of the Bell System's stability and its regard for the comfort and convenience of its customers and its employees; that they are planned to contribute toward the achievement of community ideals; that they exemplify the progressive spirit which has made possible telephone communication as it is today and as it will be in the years to come.

Ever since the publication of this article, many readers of the QUARTERLY have expressed an interest in seeing pictures of other buildings of the Bell System, whether or not of recent construction. It is to meet this desire that some selected photographs of typical structures are reproduced in the following pages.

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NEW YORK CITY, LONG DISTANCE
VOORHEES, GMELIN & WALKER, *Architects*



MONTREAL, P. Q., CANADA, BEAVER HALL

BAROTT & BLACKADER, *Architects*



DETROIT, MICH., HEADQUARTERS
SMITH, HINCHMAN & GRYLLS, *Architects*



MINNEAPOLIS, MINN., DOWNTOWN

HEWITT & BROWN, *Architects*



DAYTON, OHIO

SCHENCK & WILLIAMS, *Architects*

DETROIT, MICH., UNIVERSITY

SMITH, HINCHMAN & GRYLLS, *Architects*



LOS ANGELES, CAL., HEADQUARTERS
JOHN PARKINSON & DONALD B. PARKINSON, *Architects*

MILWAUKEE, WIS., LONG DISTANCE
ESCHWEILER & ESCHWEILER, *Architects*



SAN ANTONIO, TEX., DOWNTOWN

I. R. TIMLIN, *Architect*

KANSAS CITY, MO., LONG DISTANCE

HOIT, PRICE & BARNES, *Architects*



CINCINNATI, OHIO, DOWNTOWN
HARRY HAKE & CHAS. H. KUCK, *Architects*

BRISTOL, CONN.
DOUGLAS ORR, *Architect*



WORCESTER, MASS.

DENSMORE, LeCLEAR & ROBBINS, *Architects*

PHILADELPHIA, PA., SOUTH BROAD STREET

JOHN T. WINDRIM, *Architect*



INDIANAPOLIS, IND., HEADQUARTERS

VONNEGUT, BOHN & MUELLER, *Architects*

MILWAUKEE, WIS., SHERIDAN

FRANCIS S. GURDA, *Architect*



CHARLESTON, W. VA.

MEANOR & HANDLOSER, *Architects*

FORT WORTH, TEX., CHESTNUT STREET

I. R. TIMLIN, *Architect*



LOUISVILLE, KY., DOWNTOWN

MARYE, VINOUR, MARYE & ARMISTEAD, *Architects*

ELYRIA, OHIO, LONG LINES REPEATER STATION

MILLS, RHINES, BELLMAN & NORDHOFF, *Architects*



TACOMA, WASH.

BEBB & GOULD, *Architects*

CHICAGO, ILL., MONROE

HOLABIRD & ROOT, *Architects*



SAVANNAH, GA.

MARYE, VINOUR, MARYE & ARMISTEAD, *Architects*

ALBANY, N. Y., WESTERN AVENUE

VOORHEES, GMELIN & WALKER. *Architects*



JOLIET, ILL.

HOLABIRD & ROOT, *Architects*

WASHINGTON, D. C., CLEVELAND-EMERSON

WADDY B. WOOD, *Architect*



CAMBRIDGE, MASS.

DENSMORE, LECLEAR & ROBBINS, *Architects*

DES MOINES, IA., KINGMAN BOULEVARD

JOHN NORMILE, *Architect*



WINNETKA, ILL.

HOLABIRD & ROOT, *Architects*

CINCINNATI, OHIO, EAST

HARRY HAKE & HARRY HAKE, JR., *Architects*



TORRINGTON, CONN.

R. W. FOOTE, *Architect*

ATLANTA, GA., RAYMOND

MARYE, VINOUR, MARYE & ARMISTEAD, *Architects*



WESTFIELD, N. J.

VOORHEES, GMELIN & WALKER, *Architects*

STATE COLLEGE, PA.

LAWRIE & GREEN, *Architects*



CHEYENNE, WYO.

W. N. BOWMAN, *Architect*

CLEVELAND, OHIO, CLEARWATER

HUGHES & CONRAD, *Architects*

HOLBROOK, ARIZ., LONG LINES REPEATER STATION

FISHER & FISHER, *Architects*



BOALSBURG, PA.

SHARON, MASS.

DENSMORE, LECLEAR &
ROBBINS, *Architects*

JAMESPORT, N. Y.

OJAI, CAL.

G. R. MORRISON, *Architect*

The Development of Dining Service and Other Quarters for Bell System Women

THROUGHOUT the country, thousands of telephone workers, both men and women, come in daily contact with the Bell System's dining service for employees as they fill their trays with appetizing and wholesome food at cafeteria and sandwich counters, or make their selections from the more formal menus offered in the restaurants of some of the largest telephone buildings. Probably few of them, however, have an appreciation of the extent of this service or stop to think of the amount of planning required to provide the dining rooms and kitchens and keep the service functioning.

Bell System dining service, itself a very sizeable undertaking, is an integral part of the responsibility of furnishing telephone service to the public. Meals are furnished in 400 buildings of widely varying size. There are few really large dining service units: only 10 have receipts of \$200 a day or more, while in 210 places receipts do not exceed \$25 a day. The successful operation of a large number of small and medium sized dining rooms in scattered locations is perhaps the major problem. Lunches are served in all of the units, breakfasts and suppers as well in many places, and in the largest buildings food is available 24 hours a day. In addition to week day service, which is furnished in all of the dining rooms, meals are served also on Sundays and holidays in many places. Total receipts approximate \$4,500,000 annually. Here is a self-contained business operated within the telephone business by telephone people and comparing in size and importance with the over-all operations of many outside concerns which are in the cafeteria and restaurant business as their sole endeavor.

The dining service to which telephone employees of today

are accustomed started from the simplest beginnings. The first so-called lunch rooms were installed to provide telephone operators with a place where they could eat the lunches which they brought from home. They could not make the journey to their homes and back again to the office during their lunch periods because of the distances, and in most cases there were no suitable outside eating places near enough to the central office for them to use. In those few locations where suitable outside places were within reach, difficulty was experienced by employees whose lunch periods came before or after the usual meal hours in obtaining food of good quality at such times. The need for providing lunch rooms in the buildings where the operators worked became obvious.

SERVICE IS EXTENDED TO ALL EMPLOYEES

At first, tables and chairs were provided. Later, gas hot-plates were installed for the operators to use in preparing coffee and tea and for other light cooking. Then matrons were engaged by the Companies to wash the dishes; later, these matrons started to serve food and the menus were increased in scope. Some years ago, numerous requests from the employees led to the extension of the operators' dining service to include the female employees of the other departments and then the male employees. A still further development was the establishment of dining service in some of the headquarters buildings. Among other advantages, such service furthers friendly contacts between the employees of all departments, and also, as in the other buildings, is a great convenience to the employees, particularly in inclement weather.

In all of this work the American Telephone and Telegraph Company's headquarters staff has for many years been rendering important services to the Associated Companies. As the size of the undertaking increased, many and varied questions arose and numerous inquiries from the field were received. The situation was studied, and soon it was found desirable to

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extend the facilities of the Department of Operation and Engineering to include the dining service job. The scope of this assistance is comprehensive and reference is made further on to many of the important matters covered. So that each Company will be in a position to profit by the combined experience of the System as a whole, the O. and E. Department of the headquarters company maintains close contacts with the dining service people all over the country. These contacts also extend to commercial cafeteria concerns and manufacturers in the equipment field.

The dining service is operated almost entirely by the Traffic Departments of the Operating Companies because it was started for the operators and continues to receive its greatest use by the female operating forces. In the smaller cities, the Chief Matron, meaning the employee in charge of the dining room, reports to either the Chief Operator or the District Superintendent of Traffic. In the large cities, the operation of the dining service, as it developed, became complex, and dining service departments have long been established. These departments supervise the operations in all the units, sometimes including those in the smaller cities of the same area or company.

DEFINITE OBJECTIVES ARE ESTABLISHED

In operating the dining service, there are definite objectives or aims which the managements strive to accomplish. These pertain to the service furnished and to the costs. It is aimed to render a service which is liked by the employees who are served. This includes the types of foods offered, the daily variety and quality of the food, the promptness and grade of the service, the cleanliness of the quarters, and the other features of a food service which the customers of any cafeteria or restaurant consider important.

In the early days there was a wide variety of practices as to costs. In most cases food was charged for; in a few instances

there was no charge. Beverages were furnished free in some cities; in others they were sold. Practices are now practically uniform throughout the System. The free service has been discontinued because it was found that employees preferred to get the money as wages and spend it in their own way. Generally speaking, prices are fixed at approximately the levels which apply in local commercial cafeterias serving food of comparable quality. The dining service, of course, is not operated to make a profit for the companies, though it might seem that if outside prices were approximated and the managements were efficient, a profit would ensue. However, in many cases dining service is furnished under conditions where it cannot be operated with full efficiency: in small places, and during off-hours and on Sundays and holidays in the larger places; and instead of a profit, a small deficit is unavoidable. In the commercial restaurant field, to ensure a good return, cafeterias are not operated under these conditions, but in the telephone business there is a particular need for such food services from the standpoint of working conditions.

CORRELATION WITH THE REQUIREMENTS OF THE BUSINESS

The operating problems encountered in meeting the objectives are, of course, those of a technical nature which any commercial restaurateur experiences, plus those of correlating the dining service with the requirements of the telephone business. A complete set of operating methods and practices, formulated by the American Company, was an important contribution in this regard. This material has been supplemented from time to time with many sets of suggestions relating to current problems. Also, numerous conferences on the subject have been conducted in various parts of the country and attended by representatives from all the Companies. The job in its entirety is being well handled by the many dining service people involved, and as a result the employees generally are proud of

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"their dining room" and of the kind of service "their matrons" furnish.

When a new building is planned, conditions are studied to determine whether or not any dining service facilities will be required and, if so, what kind. In the smallest offices, where all of the operators go home for lunch, nothing is needed. In larger offices, where a few of the operators stay in for lunch, a kitchenette is provided, consisting of a small stove, refrigerator, sink, and dish cabinet, together with one or two dining tables and some chairs. The kitchenette is located either in a small room or in the sitting room (referred to later on) and screened therefrom. Where there are enough employees to warrant a regular meal service in the building, a cafeteria is provided. These cafeterias range in size from small units, with the kitchen, counter, and dining space combined in one small room, to large installations with a central kitchen and bakery supplying several cafeterias on different floors. In a few headquarters buildings, a sandwich shop also is provided, as well as a restaurant for those who prefer that form of service and are willing to pay for the additional expense involved. In all cases the arrangement must, of course, permit efficient operation during the peak serving periods, and also during the off periods, when the dining service force is reduced considerably in size.

ENGINEERING THE DINING SERVICE LAYOUT

The layouts are made by the Traffic and Engineering Departments of the Associated Companies concerned, frequently with their architects participating. On the more important projects, copies of the proposed plans and specifications are usually sent to New York for review by the O. and E. Department and frequent field trips are made by members of that group for the purpose of discussing the contemplated work with the engineers concerned. After completion, plans and photographs of many of the installations are obtained by the

O. and E. Department for such uses as may develop elsewhere in the System.

In addition to engineering dining service quarters for new buildings, an important part of the layout work is the remodeling of old quarters in buildings where the number of employees has changed considerably or where the equipment has worn out or new practices have been introduced. Sometimes it is a general rearrangement of the kitchen and counter; or a new dishwashing room with a modern washing machine, sink, and dish table; or a sandwich counter to permit making sandwiches to order—a recent addition to the facilities in numerous locations. The planning of these jobs requires care and oftentimes the details involved in making over an old installation are more difficult than when new quarters are designed.

As to the equipment, the amount provided varies, of course, with the size of the office. The objective is to provide adequately for the needs, but on the other hand to avoid purchasing equipment which is not required or which is too large. In selecting the equipment, many factors are involved, among which are safety, durability, ease of keeping it clean, and the cost. Appearance is also a factor, particularly where the equipment will be visible to the customers. Stainless metals are used for purposes where experience indicates the added cost to be warranted. Wherever possible, standard commercial equipment is used—ranges, refrigerators, dishwashing machines and so forth. Some items of equipment are not, however, available ready-made in the sizes required—counters, steam tables, range hoods, etc.; and these are specially constructed by contractors under Company specifications that define the requirements in detail.

In this layout and equipment work, including the furnishing and equipping of the other quarters mentioned further on, an "Operators' Quarters Engineering and Equipment Handbook" prepared by the Department of Operation and Engineering is used widely by the Associated Companies. This has been

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available for many years, and, of course, is revised from time to time to keep it up to date. The Handbook has been a great help to the field people, particularly in many of the Associated Companies where there is not enough of this kind of work to warrant assigning a specialist to it. If a field man wants to know how much space ought to be provided for the kitchen or dining room, or what equipment will be needed in a cafeteria of a certain size, running all the way from ranges and dishwashing machines down to pots, pans, silverware and dishes, or how the major items of equipment should be arranged, he can turn to the Handbook and obtain the answer. If he wants to buy kitchen machinery or other ready-made articles of equipment, he can find out about types known to be satisfactory for his particular requirements. If the counter, cold pan, or other articles of equipment, not available ready-made, have to be fabricated, specifications are there covering the requirements in detail—types of construction, kinds and gauges of metals, etc. Any one in the restaurant business knows how long it takes to acquire adequate knowledge about these matters and how invaluable a complete treatise on the subject must be to one whose main experiences have been along other lines.

FURNISHING THE DINING ROOMS

In furnishing and decorating the dining rooms, due consideration has been given to such factors as appearance, practicability, and cost. Women do not like heavy furniture. Adaptations of the early American type of tables and chairs seem to be preferred and are in common use. In some of the most recently furnished rooms, furniture with modern lines has been used. The top of the table presented a problem. Numerous types were experimented with; some were noisy, some broke easily, some showed scratches and the marks of hot plates. Linoleum in various colors was finally recommended to the Associated Companies as being the most all-around satis-

factory material for the purpose. Bell System dining rooms were among the first to use this type of table top, which to-day is favored by many commercial and industrial cafeteria and restaurant operators in all parts of the country. The dining room chairs are equipped with combination rubber and metal slides to reduce the noise. Some of the largest dishwashing rooms have been sound-proofed.

The foregoing provides a general picture of the engineering side of the dining service undertaking and, as will be seen from the photographs, the modern telephone building cafeteria, with its well equipped kitchen, counter, and dining room, presents a striking contrast to the lunch rooms which preceded it in the early days.

THE PROBLEM OF PLEASING MANY TASTES

Now let's return to the operation of the service. How about the food? It has been said that one of the principal aims is to please the employees who use the service. Strange as it may seem, certain items of food that are popular in one cafeteria may not sell well in some of the other cafeterias in the same city. When this is noticed, the quality of the cooking is first checked to see whether or not the food is being prepared as well in one place as the other. If this is not the reason, it may be that the employees in one office come largely from families that have been accustomed to different types of food from those in another office. Sometimes the particular cause just cannot be determined. And so, the first step in deciding what to serve is to consider what has been learned about the tastes of the customers in the particular cafeteria involved. Further, suggestions from the employees are always welcomed and, whenever practicable, they are acted upon and with a minimum of delay. Due regard is also given to planning wholesome food combinations. Another factor in arranging the menus is the number of meals to be served. Where the volume is small, the variety is necessarily limited. In the large



ABOVE: IN THE "TEA AND COFFEE" DAYS.

BELOW: MODERN KITCHENETTE FACILITIES IN A SMALL CENTRAL OFFICE BUILDING.



ABOVE: ONE OF THE SERVICE RESTAURANTS.

BELOW: MODERN CAFETERIA FACILITIES.

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cafeterias and restaurants, a wide choice is offered. Market conditions have to be followed closely, so that the menus will include foods which may be purchased at particularly favorable prices at the time.

Food supplies are usually bought locally in each city. The centralized purchasing of foods on a System-wide basis has been studied on several occasions, but the plan was not considered feasible. Needless to say, the food standards are high. The buyers are careful, however, not to pay premiums for differences in grades which are technical in nature and not worth paying for as far as the finished item of food is concerned.

TESTED RECIPES AND PORTIONS

The Telephone Companies have a reputation for serving food that is tastefully prepared and attractively served. This did not come about by chance. Good raw materials and good cooks and bakers are obviously essential; but in addition, specific standards have been established. In other words, it is a common practice to supply the cooks and bakers with a set of recipe-portion cards which cover each item of food completely. When the need for such information became generally recognized, it was found that many of the Associated Companies had no qualified employee available for the tedious task of preparation involved. A set of cards covering 450 different dishes was, therefore, compiled at staff headquarters. A competent dietician with practical telephone company dining service experience developed the instructions, using the facilities of one of the central office kitchens in New York City, and each item was carefully prepared and checked before a decision was reached. These cards were then sent to the Associated Companies for such use locally as seemed desirable. As was expected, revisions have been made from time to time to fit local conditions, and new dishes have been added. Many valuable suggestions in this regard have come from cooks and bakers who are on the lookout for new dishes that might be served

and for better ways of doing their particular jobs if they can be found. The cards also cover the size of the portion to be served for each item. Obviously, there could be a considerable loss, as well as dissatisfaction among the customers, if the many thousands of portions which are served daily were carelessly measured. This method of control is standard in the chain restaurant and cafeteria field.

APPEALING TO EYE AND PALATE

The appearance of the cafeteria counter is a matter that has received due attention. While there is no attempt to sell the employees food they do not want, there is the same care in displaying the food properly as in preparing it. The counters are equipped with steam tables and glass display cases. The covers are removed from the steam table containers during the busy periods so that the food may be readily seen. Glass protectors in front of the steam table protect the food, while at the same time permitting a view by the customers. In arranging the food at the counter, the attendants have been carefully instructed as to the desirability of an attractive arrangement and how it may be obtained. A serving technique has been developed which is intended to make the serving of foods efficient and pleasing. It has been the aim to have the dining service forces develop a "customer" attitude toward their fellow employees on the other side of the counter.

Perhaps it would be interesting to take a quick look behind the scenes in one of the large cafeterias to see just what goes on. Here is the kitchen door. Supplies have just been brought to the kitchen floor on the elevator near the entrance into the kitchen—crates of lettuce, baskets of tomatoes, a bunch of bananas, several bags of potatoes and other items direct from the wholesale markets. Deliveries are checked and perishables are put away promptly in one of several "walk-in" refrigerators. When staple supplies are received, they are placed in the storeroom. This is equipped with sani-

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tary metal shelves and covered bins for bulk supplies. A storekeeper is in charge of receiving and issuing all the supplies.

A TYPICAL DAY'S ACTIVITIES

The cooking equipment comes to view—a long battery of ranges, a deep fat frier, a broiler, steamers, and large kettles in which soups are made. The cooks have been busy since early morning and the noon meal is well under way. Several of the employees are seen preparing and assembling salads, using crisp lettuce, tomatoes, fruit and other appetizing ingredients. The bakery is in a separate room. All pies, cakes, biscuits and muffins are made on the premises. There are several large bake ovens, an electric mixer, a work table with bins below the top for sugar and flour. The bakers have their own refrigerator.

The supervisor's office is in one corner of the kitchen. Here the menus are planned, salesmen interviewed, bills checked, and other clerical duties performed.

Lunch time has nearly arrived. Prepared foods are being sent to the various cafeterias and to the restaurant. The quantities, however, are not large. The preparation of foods in large quantities is avoided in order to keep them fresh.

The cold pans in the counters have been filled with cracked ice. Salads and cold plates are being placed on the cracked ice; bottles of milk and other cold drinks are being imbedded in the ice. The steam table is receiving its supply of soups, meats, and vegetables. Sandwich ingredients are being placed in their proper containers at the sandwich counter. Fresh coffee has been made.

The attendants are at their stations with their spic and span uniforms, ready to render their usual prompt and pleasing service. Supplies of plates, cups, and glasses are within their easy reach. Here come the customers. Isn't it interesting to watch them size up the food, first this, then that, and finally, perhaps after receiving some friendly suggestions from the ser-

vers, make up their minds as to exactly what items they would like to have on this particular day?

Over there is the dishwashing room. Used tableware is arriving and the dishwashing machine is in use. First the dishes are washed, then rinsed, all automatically. Serving trays are being cleaned. Silverware is being polished in a machine designed especially for the purpose. There are no unpleasant odors; even the garbage is placed in a refrigerated vault as soon as the cans are filled.

Later, everything must be cleaned up. Then come the operators on afternoon relief. They pick up a snack and something to drink. Then suppers are served; then the night operators have their meals; then another day begins with the serving of breakfasts and a repetition of everything that has gone on before. The big majority of the meals are lunches, with a much smaller number of suppers and relatively few breakfasts, which are served to some of the night employees coming off duty and day employees on their way to work.

SYSTEM-WIDE REPORTS ARE PREPARED

Most of the dining service employees are women. Many have had long years of service. Except in the case of a few of the specialized workers, the employees had no previous experience in the cafeteria field. Some work full time, others part time. Most of the part-time workers have other duties at home and find a part-time position most suitable to their needs. A very friendly feeling exists between the matrons and the employees served.

In operating the dining service, a careful job of cost control is involved. A cost report is prepared for each of the dining rooms every month. All of the operating costs, properly classified, are included, along with receipts and significant comparative data used for administrative purposes. Except in a few special cases, a uniform cost report is used throughout the Bell System. The standardization many years ago of this report

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and the related practices was an important step forward in controlling the cost results of this extensive business. Copies of the reports are sent to the American Company monthly and from them are prepared and sent to the Associated Companies quarterly summaries showing the comparative results for each area and for the System as a whole. The dining service managements, in addition to watching their own costs, look forward to receipt of the summaries to see how their results compare with those of the other areas. In many cases, particularly in the larger cafeterias and during periods when food costs are fluctuating widely, food costs, receipts, and the relationship of one to the other are followed more closely, usually on a weekly basis. A "Food Cost Control" record is kept in the dining rooms. The results are compared with an objective and, if there are any important fluctuations, the reasons are determined. Possible causes of overruns are the use of materials that are too expensive at the time, waste in the kitchen, and carelessness in gauging portions.

THE DINING SERVICE IN EMERGENCIES

The normal operation of the dining service is one thing; its operation during periods of emergency is another. Take, for example, the situation in the Grant Building at Pittsburgh during the floods of last March. A recent issue of the Bell Telephone Company of Pennsylvania *Telephone News* supplies an interesting description of the conditions. Most of the meat and provision stores had been flooded out. The usual delivery service had stopped, but by private car and on willing shoulders of telephone men came hams, frankfurters in 100-pound lots, tubs of butter, crates of eggs, cans of milk, baskets of bread, and other needed supplies. The elevators were not operating and all of the food had to be carried up to the eleventh floor kitchen. When the kitchen water supply stopped, that too had to be carried.

After the cooks and bakers had finished their work, every-

thing had to be carried down again to the tenth floor cafeteria. Dishes were dispensed with in favor of paper plates and cups—the washing machine could not be operated. Everything had to be done by hand, and the number of employees to be fed increased rapidly. Emergency telephone service and desk space in the building were provided for railroads, bus lines, newspapers, food distributors and others rendering an essential public service. During the early stages of the emergency, these guests of the Company also shared in the commissary supplies. It was necessary quickly to increase the force of dining service employees. For some, sleeping quarters had to be provided in the building where they worked; for others, transportation facilities back and forth from their homes had to be arranged for. Food supplies were also prepared in this building and packed and transported to other buildings as the need arose. Included in one order was a call for 250 sandwiches. The dining service employees in all such instances, whether it be flood, earthquake, or other disaster, have been resourceful and untiring in their efforts to “carry on.”

There are many pleasant interludes in the day-to-day activities in the dining rooms. Frequently, when operators leave to be married, their office associates arrange with the chief matron for the preparation of a special meal, with a party cake and other good things to eat. Tables are pushed together and decorated with crepe paper, flowers, and favors. Sometimes it is an anniversary for one of the central office employees, or a retirement party for another. The matrons like to participate in these affairs, which provide a pleasant change from routine duties, and they do everything possible to make each one successful.

NUTRITION COURSE FOR WOMEN

The Nutrition Course for Women also comes in the category of special activities in the dining rooms. This is an optional out-of-hours course and was launched in the Fall of 1929 to

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supplement the already popular General Health Course for Women. Included in the Nutrition Course is considerable practical work in the preparation of food by the operators and other employees participating. Existing kitchen facilities in the telephone buildings are used for this purpose. The dining service people coöperate splendidly in this work and are glad to assist the instructors in the more practical features of the course. Many of the matrons have themselves taken the Nutrition Course. To date, approximately 1,000 classes have been held, with an enrollment of over 10,000 students. At the termination of the course, each class prepares and serves a meal in the dining room, partaken of by the students, instructors, and other employee guests.

All of the varied details of the dining service job—the planning of layouts, buying of equipment, hiring of employees, planning of menus, purchase, preparation and service of food, plus other necessary tasks—truly represent an extensive enterprise: the operation of a large chain of cafeterias in all its many phases, a fundamental working conditions activity that takes its place with numerous other activities of importance in the proper functioning of the Bell System as a whole.

The facilities provided for the female operating personnel do not stop with the furnishing of dining rooms. About the time the latter were installed, so-called rest rooms or sitting rooms were provided for the operators to use during the remainder of their meal periods after they had eaten, while on their 15-minute morning and afternoon reliefs, and at such other times as they are in the building and off duty. These rooms are provided in all but the very small offices. A visit to one of the large rooms usually shows some of the employees sitting around in small groups and “just chatting.” Others are seen playing bridge, listening to the radio, telephoning, or reading books or magazines selected from the reading matter provided by the Company.

DEVELOPMENT OF THE SITTING ROOMS

The development of the sitting rooms and the changes which have taken place through the years have been as marked as in the case of the dining rooms. Many different types of furniture have been used: heavy "mission" furniture with leather covered seats and plain wooden backs, overstuffed furniture, willow furniture, and the present type of graceful wooden furniture chiefly of early American design, with loose seat cushions, loose pad backs, and attractive upholstery fabrics. This furniture is strongly made, though not too heavy, and is sanitary. Chairs and settees are provided in different sizes, so that all employees can find seats which are comfortable to them. The upholstery is usually in slip-cover form, which facilitates the required cleaning. Care has been exercised to provide the right atmosphere in these rooms; what is desired is a homey, pleasant room and one which is not overdone or ostentatious. The views of the employees are, of course, obtained and followed as far as practicable in the selection of the furnishings, particularly as regards color schemes.

These are the employees' "own rooms." They take pride in them and are careful to keep them neat and orderly. Other uses for the sitting rooms sometimes arise, such as a central office party or other get-together. During the holidays, Christmas trees are decorated by the girls. In some places they assemble baskets for the poor and invite children in for a celebration before the gifts are distributed. The employees take a genuine interest in all such activities, which undoubtedly are among the features that make telephone work as pleasant as it is.

In the medium sized and large offices, a so-called quiet room is provided for the use of female employees when indisposed. These rooms are equipped with one or more day beds, chairs, and other necessary furniture. A Bell System first aid cabinet is at hand, with a carefully selected list of standardized sup-



ABOVE: ONE OF THE EARLY SITTING ROOMS.

BELOW: VARIED ACTIVITIES OCCUPY EMPLOYEES' OFF HOURS IN THIS COMFORTABLE SITTING ROOM.



ABOVE: EMPLOYEES CONTRIBUTE MUCH TO THE HAPPINESS OF OTHERS
DURING THE HOLIDAY SEASON.

BELOW: GRADUATES OF THE NUTRITION COURSE WITH THEIR INSTRUCTOR AND GUESTS
ENJOYING A MEAL PREPARED AND SERVED BY THE CLASS.

plies and the necessary instructions. The importance of being prepared to render first aid treatment to the employees in minor emergency cases—bruises, cuts, sprains, neuralgia, toothache, etc.—has long been recognized in the Bell System. However, prior to the adoption of the present arrangements, there was a considerable variation in the practices, and some were better than others. The standard cabinet, supplies, and instructions were developed under the supervision of the Medical Director of the American Telephone and Telegraph Company and embody the most suitable practices for the purpose. Only such remedies and directions are provided as can be safely used by lay people in the absence of a physician. To aid in insuring an adequate supply and also a systematic arrangement of the containers, the inside back of the cabinet is printed to indicate the proper contents of the cabinet and the intended location for everything. The instructions are attached to the inside of the door. This emergency cabinet is also provided in many offices that do not have a quiet room. In the very smallest places, a simplified stock of supplies is kept by the Chief Operator.

In the locker rooms, metal clothes lockers, adequately ventilated, are provided. Umbrella racks, with a locking compartment for each umbrella, are available in the larger offices.

The sitting, quiet, and locker rooms are shared generally by the female employees of all departments, except that in the largest buildings separate rooms are provided for different groups of people.

Operating costs of the sitting, quiet, and locker rooms are reported on a uniform basis. Copies of the reports are sent to New York regularly, and summaries are supplied to the field showing the comparative results.

And thus the story of another of the many diversified and interesting phases of Bell System operations is told. At one time the Bell Telephone Companies were among the very few concerns that provided dining rooms, rest rooms, and other

quarters for their employees. Now, the desirability of good working conditions is recognized in industry generally, and many other employers are doing the same thing. However, as was to be expected, the Bell System has kept up to date in this field also, and, as in the early days, is still a leader in providing wholesome and attractive working conditions for its employees.

R. A. STEELMAN

The Bell System Historical Museum

(Continued from the July, 1936, Issue)

TELEPHONE SWITCHBOARDS

The development of the telephone switchboard proper occupies one corner of the museum adjacent to the central office apparatus exhibits. There is a case of very early switchboards shown in Figure 11. Some of the early switchboards exhibited on the floor as well as groups of photographs depicting manual switchboards through the years to the modern panel type central office are shown in Figure 12.

At the top center of the case, Figure 11, is the original first telephone exchange switchboard. It was designed by E. T. Holmes, who conducted a burglar alarm system in Boston, and was built by Charles Williams. Box telephones were installed in the offices of some of the subscribers to the burglar alarm system and were connected to this switchboard over the burglar alarm wires. Signaling was effected in both directions by the burglar alarm apparatus. The lines were first placed in service on May 17, 1877. The switchboard, however, was later discontinued because the subscribers were not willing to pay for a luxury, as the telephone was then considered. It was the first switchboard to be used to interconnect telephones installed in different buildings.

On the following January 28, 1878, the first commercial telephone switchboard in the world was opened for regular service in New Haven, Connecticut. It was designed by George W. Coy. A model of this board and two subscriber sets are on display at the rear of the Museum. In Figure 11 immediately below the Holmes switchboard, is the original switchboard and calling annunciator installed in Meriden, Connecticut, January

31, 1878. It was the second commercial switchboard in the world to be placed in service. It was designed by Ellis B. Baker and follows closely the pattern of the New Haven board. In both these early switchboards, the subscriber set (see Figure 7), consisted of a push-button to call the central office and a wooden hand telephone, used both as transmitter and receiver. The signaling arrangement at the switchboard to call the subscribers consisted of a "Watson buzzer" or a "Coy's chicken," as it was dubbed at New Haven. A vibrating spring interrupting a current amplified through an induction coil caused the diaphragm in the hand telephone at the subscriber's station to howl. Thus the subscriber's hand telephone at first had three uses—transmitter, receiver and signal. The operator's set was also a hand telephone.

Immediately to the left and to the right of the Holmes switchboard are the first and second switchboards installed in Philadelphia in 1878 and 1879, respectively. They were made by Williams of Boston and are essentially telegraph peg boards adapted for telephone switches. The Philadelphia telephone people were former telegraphers and preferred this type of board to the New Haven type with its lever and stud connections. The square board at the right of the Meriden board is an early Detroit switchboard designed in 1879 by W. A. Jackson, who later became president of the Michigan Bell Telephone Company.

To the left of the Meriden board is the Western Electric Company's universal telephone switchboard of 1879, the first switchboard to be made by that company. Among other features, it used the Scribner jack knife switch, and had plugs attached to cords for both answering and calling. The operator's set consisted of the Brown handset of 1879. Other smaller switchboards in the case are of the Williams type peg boards, a section of a Gilliland board, a Watson slide switch and others, practically all of them based on the telegraph type of cross-connecting switchboard.

THE BELL SYSTEM HISTORICAL MUSEUM

In Figure 12 at the left is shown the original Golden, Colorado, Gilliland switchboard installed in 1880. Underneath, in its temporary location, is a unit of carrier current equipment used in the first commercial multiplex telephone and telegraph lines installed between Tuxedo, Maryland, and Brushton, Pennsylvania, for the Washington-Pittsburgh service in 1918. At the right of the photograph is shown a section of the Lorimer system of machine telephony that was in use to a limited extent in 1906. Other switchboard exhibits nearby, not illustrated, are a section of the Law multiple switchboard at St. Louis, Missouri, installed in 1880; a quaint hotel switchboard used in the Stewart Hotel, San Bernardino, California, in 1881; and a hand-made switchboard used in Montfort, Wisconsin, in 1898.

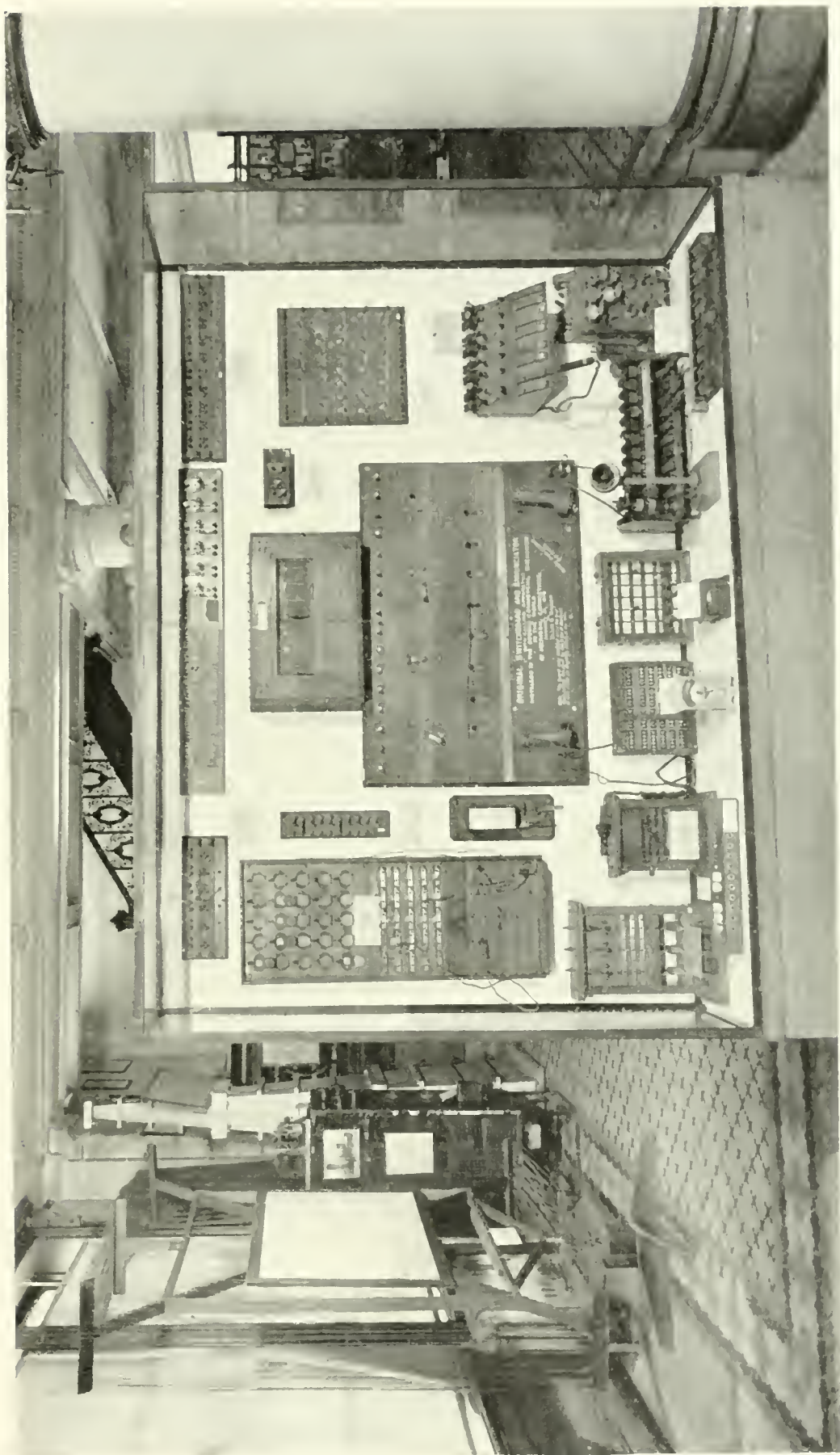
In the museum files are photographs of a very large number of switchboards, illustrating their continuing development. On display are found photographs of some of the more important types, as shown in Figure 12. In the large panel these include, among others, the first switchboard at New Haven, Connecticut, 1878; the Gold and Stock exchange at New York, 1879; Bridgeport, Connecticut, 1878; Portland, Maine, 1885; a Charles Williams, Jr. spring jack central office switch installed in Montevideo, Uruguay, in 1882 and still giving service as late as 1920; the Cortlandt, New York, branch terminal board of 1887; the Terre Haute, Indiana, board of 1897; North Office, Chicago, 1900; Canal Street, New York, manual A board of 1928 and the dial A board for the Worth and Rector panel exchanges, New York City, 1931. On the walls, beginning at the left, we see photographs of the first common battery exchange at Lexington, Massachusetts, December, 1893; the first common battery multiple switchboard at Worcester, Massachusetts, 1896; at the right the first semi-mechanical exchange at Newark, New Jersey, January, 1919; and a part of the equipment of the first full automatic panel system cut into service in Omaha, Nebraska, December 10, 1921. Other photographs

not shown include views of the Telephone Dispatch Company's central office in Boston in 1883 and Law type switchboards in Richmond, Virginia, 1882, and Lynchburg, Virginia, 1898.

EARLY DEVELOPMENTS NOT ASSOCIATED WITH THE BELL ORGANIZATION

So far, we have followed sequences of development somewhat in the order of their introduction in the telephone plant. Let us now view the collection of early developments of other early workers, who, at the time, were not associated with the Bell organization.

The early work of Thomas A. Edison with his carbon transmitter is shown by over two dozen different models, most of them originals, from 1877 to 1880, and some of which show improvements by Scribner and Phelps of the Western Electric Company. There is a shelf devoted to originals and models of the Emilie Berliner loose contact transmitters of 1877 and various modifications made during 1878. Another shelf is occupied with models of Elisha Gray's liquid transmitter of 1876 and various forms of transmitters and receivers designed by him in 1877 and 1878. Several examples of transmitters and condenser receivers designed by Amos F. Dolbear are also shown. Examples of the work of these men appear in Figure 13. Then, there is quite a large group of models of telephonic instruments that were made in connection with the extended litigation of the Bell patents to illustrate to the courts how these instruments were supposed to operate. Among these are models of the Reiss transmitters and receivers of 1861, '62, '63; Wrentham rods of 1863; House transmitter of 1868; Van der Weyde's, Drawbaugh's, Voelker's and Randall's transmitters of 1879. A discussion of the claims put forth in favor of these instruments does not fall within the scope of this article. There is also a group of about 100 different infringing telephones collected by the Bell Company during the period of liti-



Group of Early Switchboards.
FIGURE 11



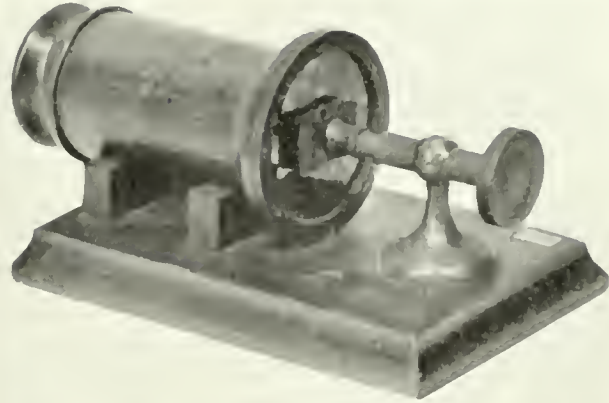
Early Switchboards, and Photographs of Multiple Switchboard and Dial Switching Developments.

FIGURE 12



Model of Gray's Liquid Transmitter: 1876.

Model of Berliner's Loose Contact Transmitter: 1877.



Edison's Experimental Apparatus for Using Lamp Black in Transmitters: 1877.



Sample of Dolbear's Condenser Receiver: 1880.

FIGURE 13



*Phelps Double
Crown Telephone:
1879.*



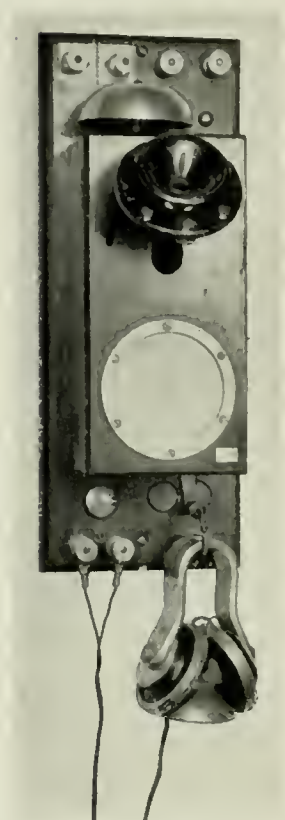
*Gray's Bat-
tery Tele-
phone: 1879.*



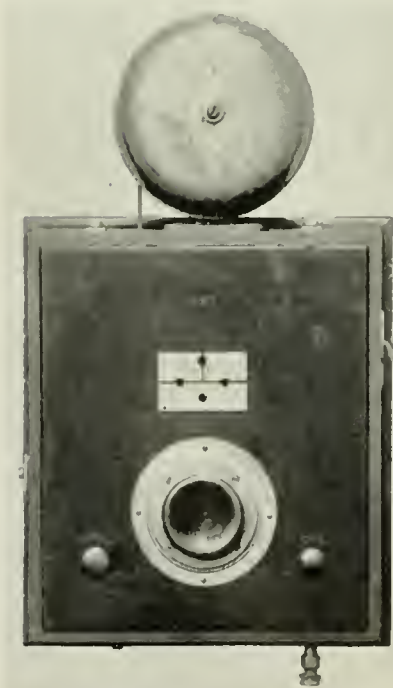
*Phelps Pony Crown
Telephone: 1880.*



*Phelps-Edison Set with Sin-
gle Crown Receiver: 1879.*



*Chicago Set with
Gray's Bipolar
Receiver: 1879.*



*Large Califor-
nia Edison
Set: 1879.*

*Phelps Long
Line Magneto
Box: 1879.*



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gation and used as exhibits in court cases during the many actions brought in defending the Bell patents.

THE AMERICAN SPEAKING TELEPHONE COMPANY'S APPARATUS

The Western Union Telegraph Company, through its subsidiary the American Speaking Telephone Company, organized in December, 1877, and the latter's agent, the Gold and Stock Telegraph Company, was perhaps the most serious contender against the Bell Company. The telephone instruments which the Western Union used were constructed on the plans of Edison and Gray and George M. Phelps, the then superintendent of the New York shop of the Western Union Company. Some of the telephone instruments were made in this shop and others in the shop of the Western Electric Manufacturing Company in Chicago. Many thousands of telephone instruments and numerous telephone switchboards were in use up to the time that the Bell Company began a suit on September 12, 1878, to be settled out of court on November 10, 1879, resulting in the withdrawal of Western Union interests from the telephone field.

There is one case full of exhibits of the American Speaking Telephone Company's apparatus, most of which was made in the Western Electric shop and some in the California Electrical Works shop in San Francisco, the Pacific Coast agent. The general appearance of these exhibits attests to the early reputation of the Western Electric Manufacturing Company as a manufacturer of the highest grade of electrical apparatus. Some of these instruments are shown in Figure 14.

VACUUM TUBE REPEATERS

The introduction of the vacuum tube repeater in the telephone plant has, perhaps, more than any other unit of apparatus, led to the rapid extension of wire and radio telephony. Its application in telephony began with the first use of a high vacuum three element tube as a telephone repeater at Phila-

delphia in the regular New York-Baltimore wire toll circuits on October 18, 1913, this being preliminary to their introduction in the transcontinental circuit from New York to San Francisco opened January 25, 1915. These were three electrode high vacuum thermionic tubes, first produced by Harold D. Arnold, from the basic three electrode audion, invented in 1906 by DeForest, one of the pioneers in radio.

During September and October of that same year, 1915, in wireless telephone tests the human voice was projected for the first time beyond this country, from Arlington, Virginia, to Paris, France, and to Honolulu, H. T.

The vacuum tube case shown in the front center of the frontispiece contains the exhibits portraying the more important stages of tube development.

VACUUM TUBES WITH HISTORICAL ASSOCIATIONS

A model of the "Edison effect" of 1883 is followed by a model of the Elster and Gietel tube for the study of thermionic discharges and other early tubes of Von Lieben and Fleming previous to a sample of DeForest's three element tube of 1908. A sample of Arnold's mercury arc repeater of 1912 bridges the gap between the Shreeve mechanical and Arnold's high vacuum tube telephone repeater of 1913. There are a large number of laboratory experimental tubes from this time on, up to and including war time developments, 1917-1918, of our own and other American manufacturers as well as a number of European tubes of the war period. With the development of the seal between copper and glass the high power water cooled tubes came into existence in 1920. The experimental 4 KW tube of that date was a tremendous advance from the 25 watt air-cooled power tube in the 1915 transoceanic tests. Next came the 10 KW, and in 1922 an experimental 100 KW single-ended tube was constructed and tested. This tube preceded by many years the commercial 100 KW double-ended tube. A group of low voltage cathode ray oscillograph tubes are

shown as well as Davisson and Germer's electron defraction and polarization tubes of 1926-27. Among the tubes used in noteworthy events are: one of the 500 twenty-five watt air-cooled power tubes used in the Arlington-Paris-Honolulu tests of 1915; a 10 KW water-cooled tube used in the first sustained radio telephone talk across the Atlantic, January 23, 1923; a tube designed for and used in the radio airplane transmitter on Byrd's first successful flight across the North Pole, May 9, 1926; and an air radiation tube, 1 KW, used on the steamship Leviathan at the inauguration of ship-to-shore radio telephone service, December 8, 1929. A group of vacuum tube exhibits is shown in Figure 15.

MODERN VACUUM TUBES AND PHOTO-ELECTRIC CELLS

Adjacent to these historical tubes is a case containing a display of the various types of commercial vacuum tubes developed by the Laboratories for all the various parts of the telephone plant both wire and radio at the present time. There are some 70-odd tubes ranging in size from the small "peanut" type 2 11/16 inches high to the 100 KW amplifier 4 feet high. Photoelectric cells form an interesting group ranging from the small cell used in the transmission of photographs over telephone circuits in 1924, to the cells for sound film reproduction, and those used in our television demonstrations. The latter include cells used in the first one-way demonstration between Washington, D. C. and New York City by wire and between Whippany, New Jersey and New York City by wireless on April 7, 1927; the out-of-door demonstration June 12, 1928; the color television demonstration June 27, 1929; and the two-way television demonstration for a distance of over three miles beginning April 9, 1930, and lasting over two years. The associated neon lamps at the receiving ends are also shown.

THE PRINTING TELEGRAPH

Printing telegraphy dates back almost to the beginning of the telegraph itself. Our earliest exhibit is that of the Gray printing telegraph of 1872 mentioned previously; other early machines include the Phelps set of 1872, the Essick page printer of 1891 as well as a Baudot (French) set of 1902. We have examples of Bell System developments of later dates but none are on display at present.

MICROPHONES AND LOUD SPEAKING RECEIVERS

The developments of microphones and loud speaking receivers for public address, sound picture recording and reproduction and radio broadcasting are shown by numerous exhibits. The earliest microphone is an Ader, a loose carbon Hughes type, used at the Paris Exposition of 1881, where broadcasting by wire was demonstrated probably for the first time. Several of these transmitters were located around the front of the stage; half were connected to the head receivers for the left ears and half to the receivers for the right ears to produce the binaural effect. (Even before this time, Bell had experimented with his magneto telephones to produce this effect. His experiments were described in a monograph read before the American Association for the Advancement of Science at Saratoga, New York, in August, 1879.) Later on, the theatre transmitter with its wooden diaphragm and granular carbon button developed in the Bell Laboratories appeared in 1899. Condenser transmitters used at President Harding's inaugural in Washington and at the burial of the Unknown Soldier in Arlington, Virginia, in 1921, mark important steps in broadcasting transmitters. This type of transmitter has for many years served several useful purposes in the development and refinement of telephone instruments in general and in the field of broadcasting, loud speaking and sound picture technique in particular. Later steps are shown by the electro-dynamic



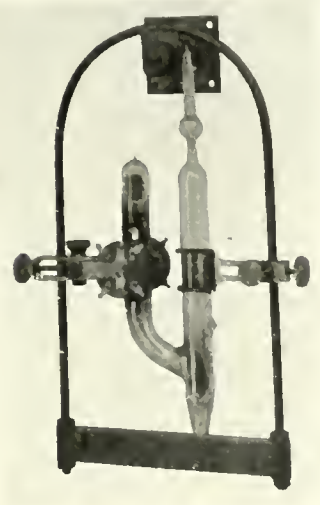
*DeForest Three-
element Tube:
1908.*



*High Vacuum Telephone
Repeater: 1913.*

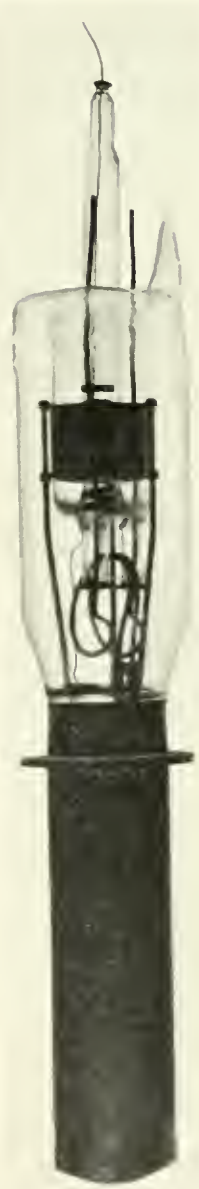


*M o d e r n
Telephone
Repeater:
1927.*



*Arnold Mercury Arc
Repeater: 1912.*

*25 Watt
Air-cooled
Power Tube
for Trans-
atlantic
T e s t s :
1915.*



*Experimental
100 Kw. Wa-
ter-cooled
Tube: 1922.*



*10 Kw. Wa-
ter-cooled
T u b e :
1923.*



*1 Kw. Air-cooled
Tube for Ship-
to-Shore Tele-
phone Service:
1929.*

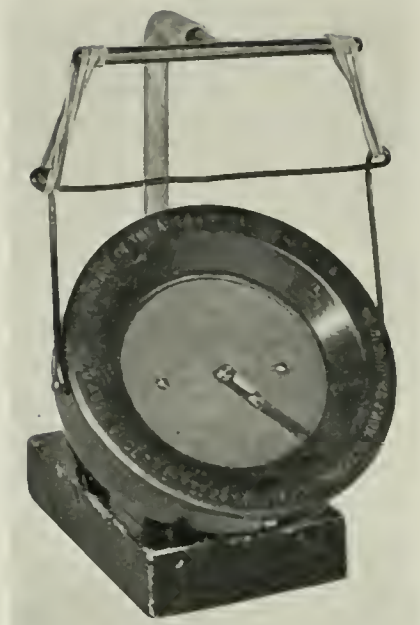


*Low Voltage
Cathode Ray
Oscillograph
Tube: 1922.*

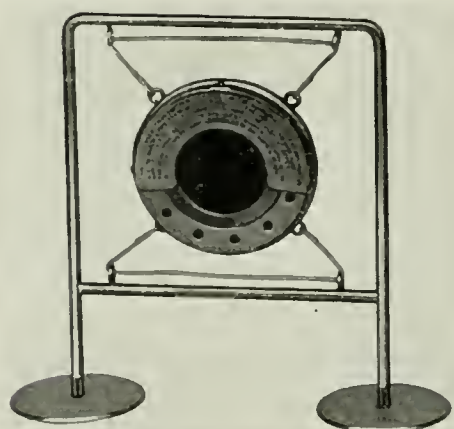
FIGURE 15



Ader Theater Microphone: 1881.



*Bell Theater Microphone:
1899.*



*Condenser Transmitter Used at
Inauguration of President Harding:
1921.*



*Electro-dynamic Microphone:
1931.*



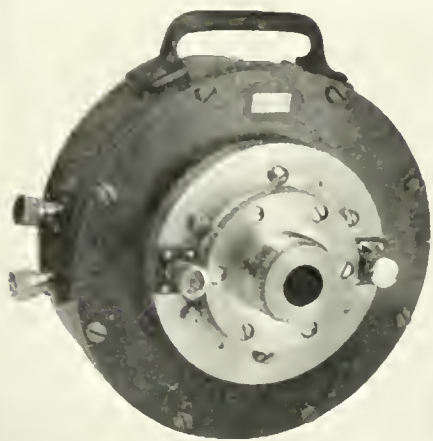
*Non-directional Microphone:
1935.*

FIGURE 16

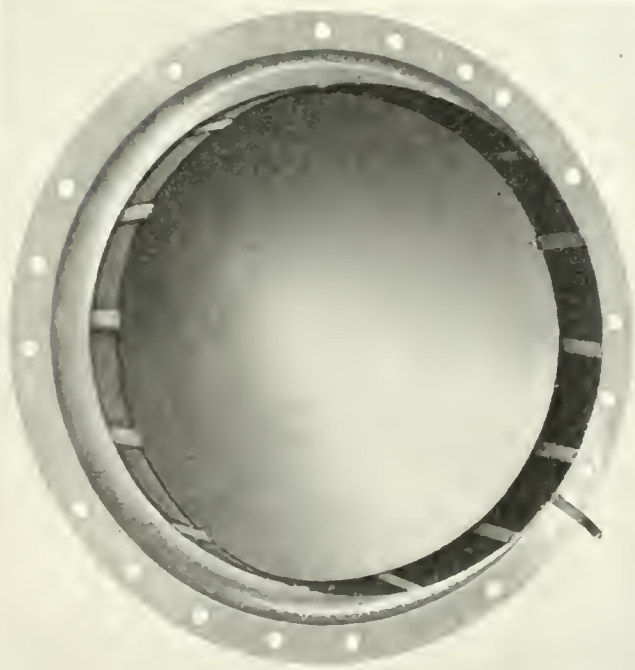
Loud Speaking Receiver Used at Harding Inaugural: 1921. (For Associated horn, see Figure 11.)



Loud Speaking Receiver (Minus Horn) Developed for Talking Pictures: 1926.

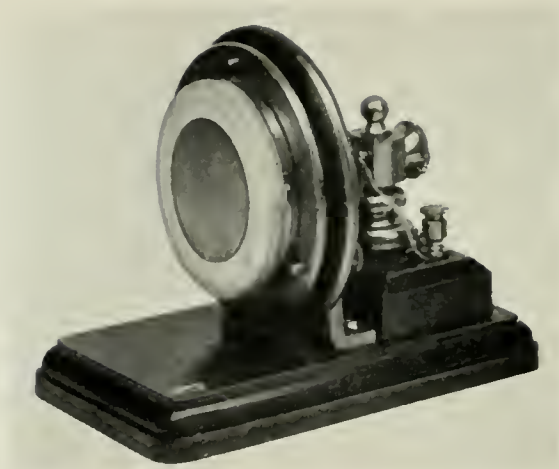


Loud Speaker Used in Paris on Transatlantic Tests: 1915.



Diaphragm of High Power Loud Speaker Used at International Yacht Races in 1934 (left) Compared with 196-Type Diaphragm of 1918 (right).

FIGURE 17



*Replica of Transmitter-Receiver Used
in First Long Distance Conversation,
Between Boston and Cambridgeport,
Mass., two miles: 1876.*



*Telephone Used in Talking Around the World,
from and to New York City, 23,000 Miles: 1935.*

FIGURE 18

THE BELL SYSTEM HISTORICAL MUSEUM

transmitter of 1931 and the non-directional moving coil transmitter of 1935. There are also several samples of air-damped and stretched steel diaphragm transmitters of the 1916-1920 vintage. A few of these microphones are shown in Figure 16.

The loud speaking receiver development has kept pace with that for microphones. Among our more important exhibits are the No. 177 type loud speakers originally designed in 1911 for train dispatching, through which were heard in Paris the first words crossing the Atlantic by wireless in 1915; one of the eight No. 196 type balanced armature receivers (and its 10½ foot horn, shown at the left of the exhibit case, Figure 11) used at President Harding's inaugural in 1921; and a No. 555 type moving coil armature, which was developed primarily for use with the Vitaphone talking pictures, first publicly demonstrated August 7, 1926. The moving coil loud speakers have been further developed both for smaller sizes than the No. 555 and for much more powerful units. We have a sample moving coil diaphragm of the high power loud speaker first publicly demonstrated during the International Yacht Races off Newport, Rhode Island, in the fall of 1934. While we have purposely avoided comparative statistical data, exception can be made in this instance to give the performance of this powerful loud speaker. It is capable of a maximum sustained output of approximately 500 watts of sound, and it has a maximum conversion efficiency of approximately 60 per cent. Figure 17 shows some loud speakers and the comparative sizes of the diaphragms of a No. 196 receiver and that of the yacht race loud speaker of 1934.

WAR TIME DEVELOPMENTS

Another group of exhibits show some war-time developments during 1917-18. A complete short range radio telephone equipment for submarine chasers, type CW-938, is mounted on a large panel at the rear of the Museum. A complete airplane

telephone set, including the ground station, the first outfit to be developed, type SCR-68, is on exhibit in the first case on the extreme right in the frontispiece. Also, there are numerous wireless telegraph outfits, seaphones, submarine detectors, and Piezo crystal submarine detectors.

EUROPEAN TELEPHONE APPARATUS

A group of foreign telephone instruments was obtained prior to the time the International Telephone and Telegraph Company acquired the foreign interests of the Western Electric Company, and covers some interesting phases of the communication art outside the United States. We have two Bell hand telephones made in England and used at Osborne House, January 14, 1878, in a special demonstration conducted by Professor Bell for Her Majesty, Queen Victoria; the Ader theatre microphone of the type used in 1881 previously described; one of the two original Dr. Reith's receivers of 1877, similar to the Bell box telephones of that year; and later English, French, German, Swedish and Antwerp type telephone sets, the majority of which are equipped with the familiar European handsets. There is a small unit of a ten-line automatic telephone system designed at the Vatican in Rome and in use in 1886; it shows a very high grade of workmanship.

We have so far seen the developments of the communication art along more or less well defined paths. The ever widening scope of related activities in the electrical transmission of intelligence, some of which may be classified as by-products, are represented by a few examples of their essential elements.

TELEPHOTOGRAPH DEVELOPMENTS

The original light valve used in telephotographic reception on a photographic film in the series of experiments of 1923 leading up to the commercial Bell telephotograph system in 1924, is shown alongside of the commercial type of light valve

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used in photographing sound records on film. The former valve was originally constructed for making experimental sound records on film in the laboratory. In Figure 6 the photographs on the wall show the developments of telephotography from the experimental work in May, 1923, on the left, to the latest telephotograph system inaugurated January 1, 1935, to transmit simultaneously an 11 x 17-inch photograph, on the right, to twenty-three different cities in the United States.

TALKING MOTION PICTURES

During 1915, when the World's Fair was in progress in San Francisco, and demonstrations of the transcontinental telephone service were made between New York and that city, a talking motion picture of Thomas A. Watson, entitled "The Birth of the Telephone," was shown many times daily, by George K. Thompson and Wilton L. Richards of the Bell System exhibit staff. This was long before the electrical recording and reproduction on discs was developed for talking pictures as a by-product of the Laboratories' researches in telephone transmission problems. The talking part of this outfit consisted of a large Edison phonograph cylinder record used with an Edison phonograph that was located on the stage in front of the screen. Its synchronous operation with the film was effected by means of a silk fish line run over ball bearing pulleys to the hand-operated Powers film projector at the rear. This outfit is represented in the Museum by one of these cylinder records. A bone conduction receiver for deaf people, 1912, and an electromagnet receiver of 1924 with a cap molded to fit the contour of the user's ear, illustrate the early work of what are now known as audiphones. The first type of artificial larynx developed in 1925, Piezo electric developments with Rochelle salt crystals in 1919-20, frequency standards of tuning forks in 1922, and later of quartz crystals in 1927, and quartz crystal oscillators for radio transmitter frequency control in 1928, are

among the exhibits of many miscellaneous by-products. The high power microscopical work of the Laboratories is represented by photographs of high magnification of some of the metals used in our apparatus.

Along the south wall of the Museum is one of the radio telephone transmitters of the Long Beach-Catalina Island radio link, the first radio toll link in a commercial telephone system, opened for service July 16, 1920. On top of the transmitter there is a rotating condenser, an important element in the first privacy system for commercial radio telephone service which was added to this radio link on June 4, 1923. Shortly afterwards a submarine cable of much greater capacity was substituted for the radio system. Nearby is the revolving radio receiver loop used in London on the occasion of the first transatlantic radio speech from New York, one way, held on January 14, 1923. These exhibits are shown to the left of the exhibit case in Figure 11.

INSTRUMENTS USED ON HISTORICAL OCCASIONS

A group of telephone instruments used in the ceremonies attending the opening of long distance telephone circuits makes one realize how the world has contracted from a communication standpoint. We see the desk set used in New York in opening the New York-Chicago telephone service in 1892; transmitters and receivers used in opening the lines from New York to Denver in 1911, and from New York to San Francisco in 1915; the transmitter at Arlington and the receivers at Paris and Honolulu, in the first transoceanic radio telephone tests in 1915, and the desk stands used in opening commercial radio telephone links to Europe and South America; and the latest, one of the telephone sets used in talking for the first time around the world, on April 25, 1935. At this demonstration, President Walter S. Gifford and Vice President T. G. Miller of the American Telephone and Telegraph Company talked to each other

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in adjoining offices in the Long Lines Building, 32 6th Ave., New York City, over a circuit 23,000 miles in length.

The telephone set used by Mr. Gifford on this occasion was presented to the Smithsonian Institution; the one used by Mr. Miller is in our collection and is shown in Figure 18. Above this set appears a replica of one of the two transmitter-receivers used in the first long-distance two-way conversation, a distance of two miles, between Boston and Cambridgeport, Massachusetts, on October 9, 1876, nearly sixty years earlier.

Along the west wall of the Museum are three large panels of photographs, one covering the period of the experimental work and the introduction of the telephone on a commercial basis; another some research and development laboratories in the present Laboratories' building; and the third, interesting events of historical significance in connection with the extension of telephone service to cover practically the entire globe.

Our trip through the Museum has now been completed.

Its exhibits have presented a cross-section of the art of electrical communication and particularly of telephony. The Museum is growing with the art it attempts to record. Its choicest exhibits, however, will always be those of the early years. Relics of those years are gradually becoming less available; and the Museum, therefore, will be interested in any that are available. Through their display it aims to perpetuate the names and achievements of the inventors, engineers and scientists who laid the foundations of the still expanding arts of electrical communication.

W. C. F. FARNELL

Notes on Recent Occurrences

HARRY BATES THAYER

HARRY BATES THAYER, former President of the American Telephone and Telegraph Company, died at his home in New Canaan, Conn., on September 3 after a long illness. He was the predecessor of Walter S. Gifford as President of the Company, serving in that post from 1919 to 1925, when he became Chairman. Upon his own request he retired to private life upon his seventieth birthday, on August 17, 1928.

Harry Bates Thayer was a New Englander. He was descended from John Alden, Governor Brewster and other New England settlers and was born at Northfield, Vt., on August 17, 1858, the son of James Carey Barrell and Martha Jane (Pratt) Thayer. After studying in the public schools of Northfield and at Norwich University, he entered Dartmouth College, from which he was graduated in 1879. His first job after graduation was that of a railway clerk in Bellows Falls, Vt. Later he became a clerk in a Northfield savings bank.

His association with the Bell System began in 1881 and extended over almost half a century. He started as a shipping clerk for the Western Electric Company in Chicago and his salary was \$10 a week. However, his ability to get things accomplished—for which he was later to become so well-known in the Bell System—must have early manifested itself, for in 1884, at the age of twenty-six, he was made Manager of the Western Electric Company's business in New York. He served as Manager from 1884 to 1902, as Vice-President from 1902 to 1908, and as President from 1908 to 1919. In 1909 he was elected Vice-President of the American Telephone and Telegraph Company, a position which he relinquished along with

NOTES ON RECENT OCCURRENCES

the presidency of the Western Electric Company when he became head of the A. T. & T. in 1919.

Mr. Thayer's association with the business covered a period of great growth. The electrical industry, at the time he entered the Western Electric Company, was truly in its infancy. Of the present great public services based upon the use of electricity, only the telegraph was commercially well established. Arc lighting as a commercial enterprise was only a few years old. Lighting by incandescent lamps had not commenced. In the Bell System there were less than 50,000 telephone subscribers. During Mr. Thayer's connection with the Bell System the plant investment rose from \$25,000,000 to more than \$3,500,000,000.

The minutes of the meeting of the Directors of the American Telephone and Telegraph Company, held on September 16, 1936, contain the following:

"This meeting records with sorrow the death on September 3, 1936, of Harry B. Thayer, one of the outstanding personalities in the development of the Bell Telephone System.

"Starting as a shipping clerk in the Western Electric Company in 1881, he became the President of that Company in 1908 and served in that capacity until 1919, when he was elected President of the American Telephone and Telegraph Company. In this position and later as Chairman he served until, at his own request, he was retired on his seventieth birthday, August 17, 1928. His contributions to the extension of telephone service in the United States, to the perfection of that service and to the development of morale and efficiency among the personnel of the Bell System were major and marked. Through his kindly personality he contributed much to the happiness of all who were associated with him and to their satisfaction in the work done under his leadership."

DR. COLPITTS TO BE IWADARE LECTURER

DR. EDWIN H. COLPITTS, Vice-President of the Bell Telephone Laboratories, has been chosen as the fifth lecturer to visit Japan in accordance with the terms of the Iwadare Foundation. The invitation, which was tendered by the

Japanese Institute of Electrical Engineers, reached Dr. Colpitts in July and specified four weeks of next spring as the period during which the addresses are to be made.

The Iwadare Foundation is so called because of the gift in 1929 of yen 500,000 to the Japanese Institute of Electrical Engineers by Mr. Kunihiro Iwadare, who was for many years Managing Director of the Nippon Electric Company, which had been organized in 1899 as a joint undertaking with the Western Electric Company for the development of telephony in Japan and for the manufacture of communication equipment. The principal of the gift is held as a trust fund and half of the income pays the expenses of selected Japanese students of electrical engineering for graduate study in the United States. The other half of the income pays the expenses of distinguished electrical engineers who are invited to give a series of lectures at various Japanese universities.

SEVENTH REDUCTION IN LONG DISTANCE RATES IN PAST TEN YEARS

THE seventh rate reduction in ten years affecting interstate long distance calls was instituted by the American Telephone and Telegraph Company on September 1. Savings to long distance users from this reduction are estimated at \$6,000,000 annually. In addition, similar rate reductions to be made by many of the Associated Companies of the Bell System will bring the total savings to the public to more than \$7,350,000 a year.

The new rates reduce the cost of long distance calls for distances of more than 234 miles. In addition, the overtime charges on all person-to-person calls after six minutes of conversation are the same as station-to-station overtime charges for the same distances. This reduction effects a saving of as much as twenty per cent in some calls.

